CHEMICAL ENGINEERING

OCTOBER 2, 1961

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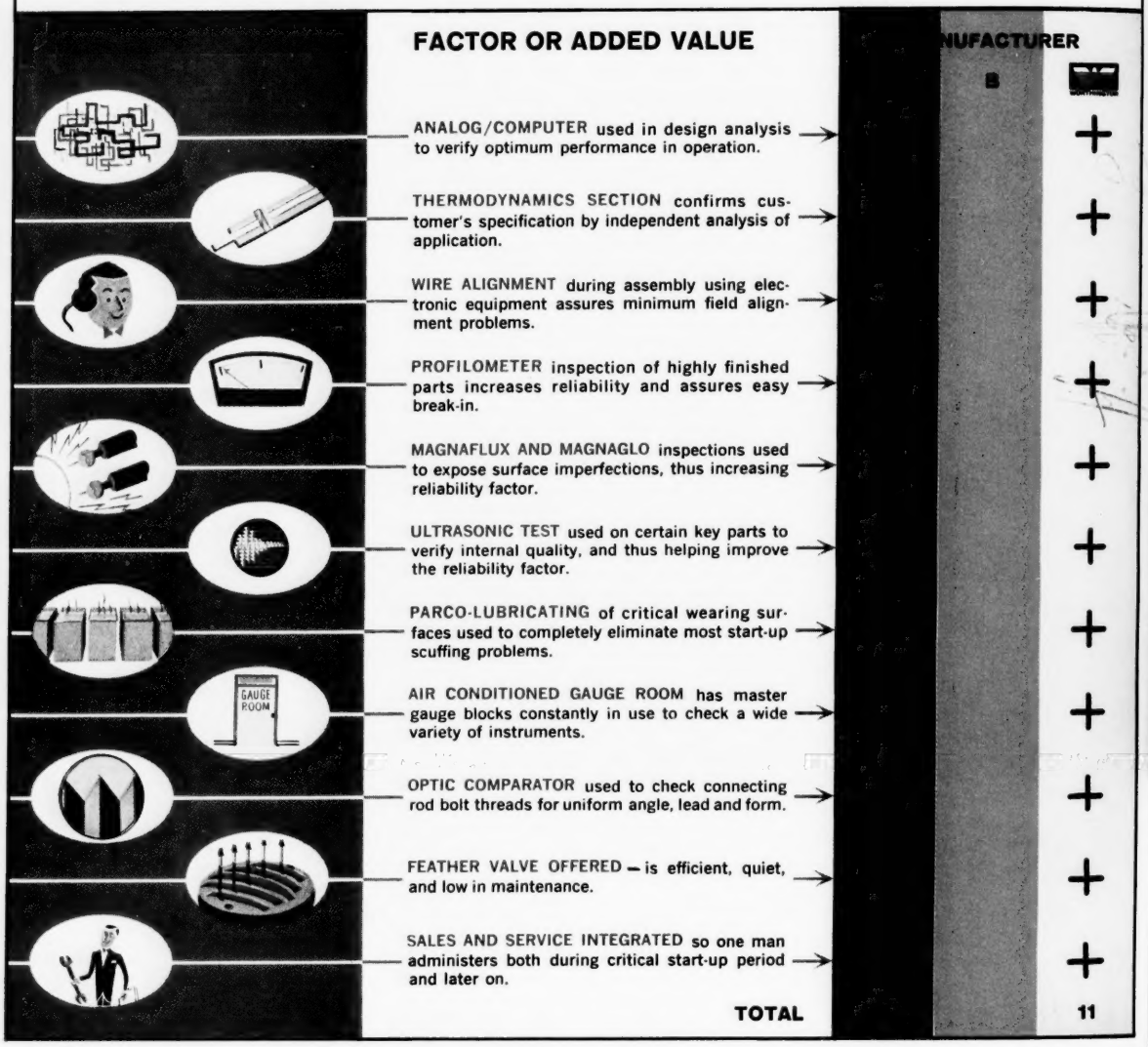
OCT 3 1961

ULTRASONICS IN PROCESSING

Complete contents—page 3

COMPRESSOR QUOTATION EVALUATION


FACTOR OR ADDED VALUE
NUFACTURER
B
ANALOG/COMPUTER used in design analysis to verify optimum performance in operation.
THERMODYNAMICS SECTION confirms customer's specification by independent analysis of application.
WIRE ALIGNMENT during assembly using electronic equipment assures minimum field alignment problems.
PROFILOMETER inspection of highly finished parts increases reliability and assures easy break-in.
MAGNAFLUX AND MAGNAGLO inspections used to expose surface imperfections, thus increasing reliability factor.
ULTRASONIC TEST used on certain key parts to verify internal quality, and thus helping improve the reliability factor.
PARCO-LUBRICATING of critical wearing surfaces used to completely eliminate most start-up scuffing problems.
AIR CONDITIONED GAUGE ROOM has master gauge blocks constantly in use to check a wide variety of instruments.
GAUGE ROOM
OPTIC COMPARATOR used to check connecting rod bolt threads for uniform angle, lead and form.
FEATHER VALVE OFFERED — is efficient, quiet, and low in maintenance.
SALES AND SERVICE INTEGRATED so one man administers both during critical start-up period and later on.
TOTAL
11

HOW MUCH IS A PRICE?

Above, you see one buyer's check-off of the hidden values buried in a Worthington compressor quotation. It helped indicate the true value of the Worthington offering. But more important than this check-off is the subject involved.

Today's rising costs and minimum profits compel every buyer to scrutinize compressor prices as never before. The problem in determining the true value of an offering is more important and, frequently, more difficult.

What's the answer? For more complete price evaluation, we suggest that you look for the "hidden value" in each manufacturer's offering—in far more detail than above. You can be sure that the true prices will separate very quickly, because "hidden" values vary sharply in the compressor market today.

To help you find, isolate and evaluate compressor offerings, we have prepared an objective "Compressor Evaluation Guide." This booklet points out the six key areas of judgment required for compressor evaluation and details them in full. Ask your Worthington Representative for this booklet or write Worthington Corporation, Dept. 36-17, Clinton Street and Roberts Avenue, Buffalo, N.Y. In Canada, Worthington (Canada) Ltd., Brantford, Ontario.

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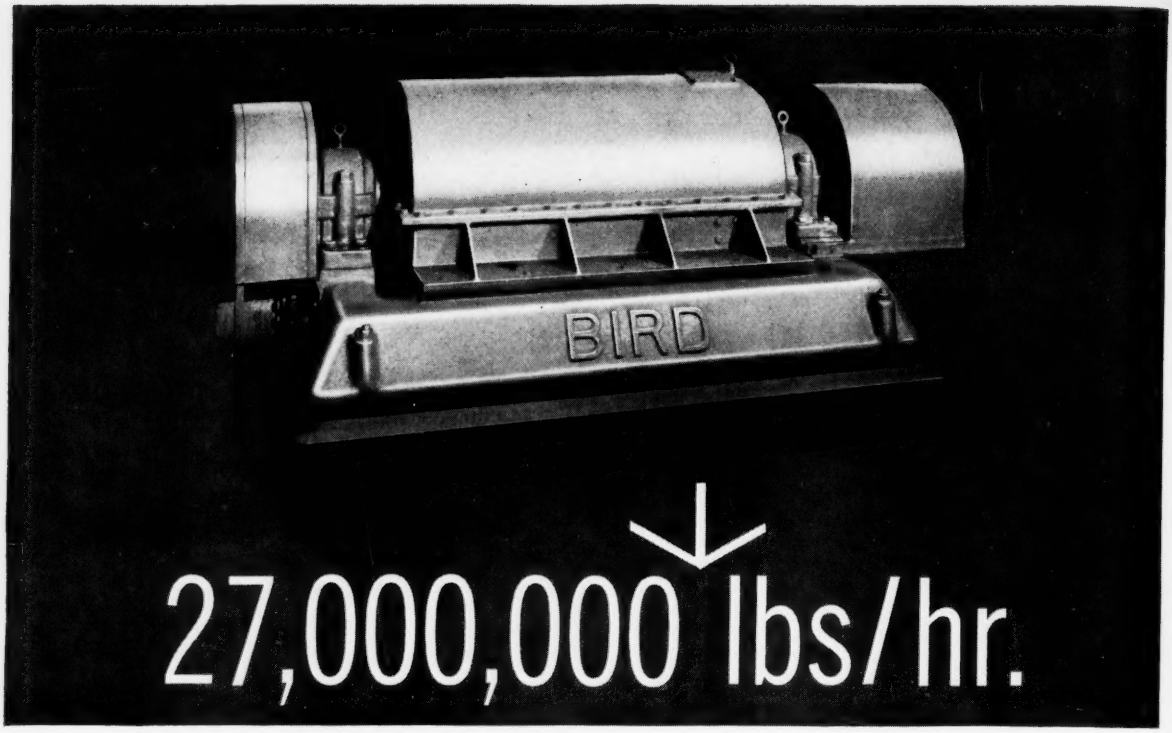

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Beryllium Sulphate	Lime Mud
Calcium Carbonate	Nickel Salts
Chromium Oxide	Pigments
Coal	Polyvinyl Resins
Copper Sulphate	Potassium Salts
Di-sodium Phosphate	Sodium Salts
Ethyl Cellulose	Starch
Flotation Products	Titanium Dioxide
Glaubers Salt	Tungsten Salts
Glutamic Acid	Zinc Salts

The producers of 27,000,000 pounds of product per hour can't be wrong. Remember this figure when you tackle a solid-liquid separation problem. Remember also that Bird also builds vacuum and other filtration equipment, can therefore put your product through comprehensive tests at the Bird Research and Development Center and come up with unbiased recommendations.

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CHEMICAL ENGINEERING

October 2, 1961

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

COVER: Part of a complex acoustic spectrum having several frequency bands is represented abstractly. An emission of this type is well suited for acoustic gas cleaning. Story on p. 83.

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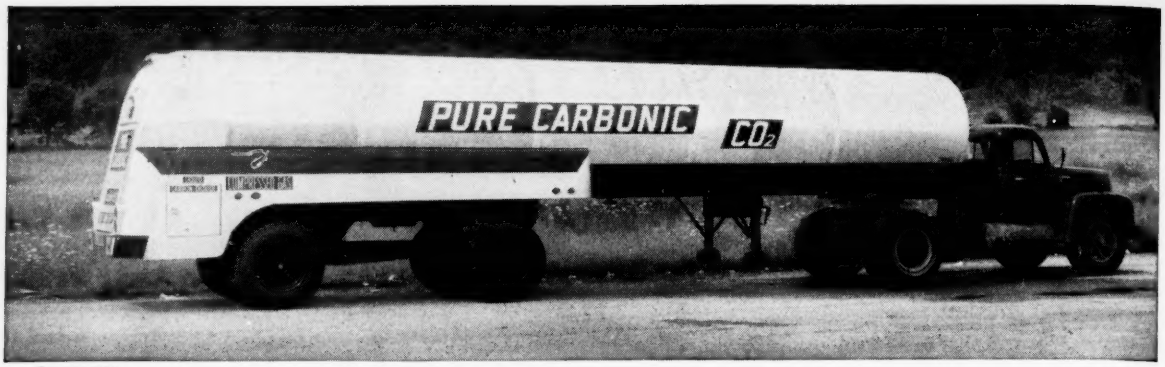

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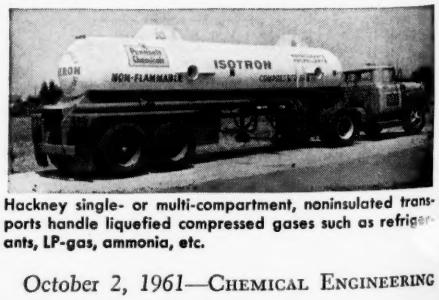

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highlights of this issue

AFRICA GETS ITS FIRST ALUMINA PLANT

Now in successful operation at Fria, Guinea, is Africa's first alumina plant, a modified Bayer process unit that required some astute chemical engineering to overcome the high costs inherent in its low-grade local ore and imported soda ash and limestone. Senior Editor Cal Cronan here reports (p. 42) on the new six-company Fria Compagnie Internationale.

HOW TO USE ULTRASONICS IN PROCESSING

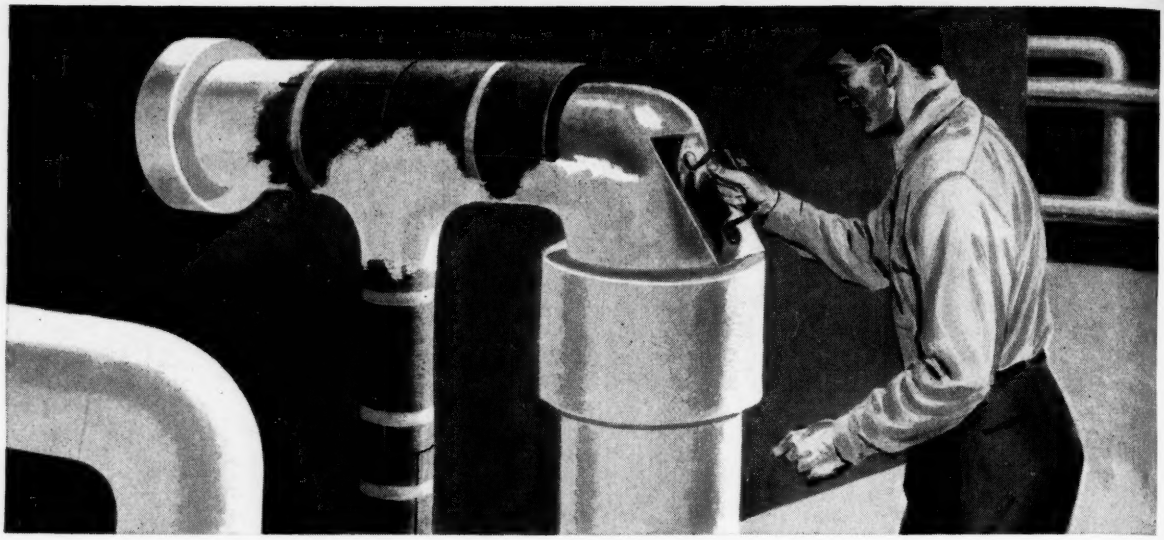
Some engineers consider ultrasonics as the processing tool of the future; others, recalling the short-lived "ultrasonics craze" of the '40's, look on it as the processing tool of the past. To form your own estimate of the potential of ultrasonics in aerosol precipitation, air pollution control, drying, foam control and rocket propulsion, read R. M. G. Boucher's 18-page Report (p. 83). Dr. Boucher, long an international authority in this field, here sheds much light on ultrasonics in processing and related uses.

ELECTROSTATIC RENAISSANCE IN THE MAKING?

Electrostatic separations are enjoying a renaissance among process industry technical men, according to consultant Les Bullock (p. 101). He credits this resurgence to improved understanding of underlying principles, new equipment, shrinking profit margins. Where other solid-solid separations fail, electrostatics may well be worth your investigation if you have a valuable product to recover.

HELP IN ESTIMATING HIGH-VACUUM COSTS

During the past 20 years, high vacuum has grown from a laboratory curiosity to a tool needed for such widely divergent tasks as metal-plating plastics, and simulating outer space. Presenting a graphical method that greatly reduces calculation, C. H. Naundorf shows (p. 107) how to make a preliminary system design and estimate its cost.



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Con: Soviet Trade

Sir:

I was intrigued by your brief item in *Chementator* (Aug. 7, p. 53) headed "Soviet technology coming to U. S. via unique exchange agreement."

This is indeed a unique agreement—all one-sided! As you say, "It has failed to interest the Soviets in buying any U. S. patent rights."

Is it not true that the Soviets refuse to honor patents or patent rights, and that much of American innovation and inventiveness has been copied and stolen by the Soviets, and that this continues today?

The second paradox in the situation is the fact that now, at a time when we are trying to conserve our gold stocks, anyone would entertain the notion that we would willingly more than double our volume of business with the Soviet Union without receiving any advantage in return, except perhaps to make a few more dollars off our own people.

Khrushchev said on March 21, 1961, "We shall be happy when the Communist banner flies over the whole planet." I believe it is thoughtless deals, such as the one referred to in your story, which are furthering the progress of his banner to the detriment of ours.

ALEXANDER A. RAMBIKUR
Alcoa, Tenn.

Sir:

Your article would be more properly titled "Soviet technology coming to U. S. via *unilateral flow* agreement." The flow refers to the $50-$100 million yearly revenue that National Patent Development Corp. estimates it will generate for the Soviet Union.

The only "unique" feature of this agreement is that a group of Americans could be so naive as to think they can interest the Soviets in buying or paying for rights that they have had access to for years free of charge—or at the most, for the price of 25¢ a copy from the patent office. The Soviet Union has clearly shown by its demeanor in world affairs that it has no respect for agreements, patentwise or otherwise.

This corporation would better serve the interests of the U. S. in turning its objectives toward the mutually profitable development of U. S. patents, thus averting the loss of $50-100 million/yr. from our own economy.

WAYNE D. HAYES
Hills-McCanna Co.
Carpentersville, Ill.

►*Our publishing this story (and the one that preceded it, July 24, p. 62) does not imply that we endorse the objectives of National Patent Development Corp., the firm involved in exchange of technology with Russia.*

Mr. Rambikur is correct in that U. S. patents are not recognized as valid in the Soviet Union; this point was clearly stated in our July 24 story. As far as the Russians are concerned, they are not stealing, merely appropriating for their own benefit what they consider to be already in the public domain. The countermeasure is obvious; but secrecy would only stifle normal economic and technological development in the Free World. President Kennedy hit the nail on the head in his speech on the Berlin crisis when he described the Soviet position as "what's mine is mine, what's yours is negotiable."—ED.

Pro: Common Thermo Errors

Sir:

Dr. Cannon has done a service in bringing to light misconceptions that have been perpetuated in some thermodynamic texts (Aug. 7, pp. 127-8).

However, my interpretation of his first problem differs from that offered by Dr. Cannon.

In evaluating the work $\int PdV$ done by an expanding gas, it is immaterial whether P is defined as the pressure of the expanding gas or as the opposing pressure of the surroundings. According to Newton's third law, the pressure exerted by the gas on the piston must be equal to the pressure that the piston exerts on the gas.

In order to find the piston velocity U after x ft. of vertical travel, the net upward force at any time t is equated to the product of mass M and acceleration:

$$PA - M - f = (M/g)\,(dU/dt)$$
$$= (MU/g)\,(dU/dx)$$

where A = piston area and f = frictional force of cylinder walls on piston sides. Rearranging and integrating between limits x_1 and x_2:

$$\int PAdx = \int PdV = MU^2/2g + M(x_2 - x_1) + \int f dx$$

Thus, the work done by the gas appears at the end of the process as an increase in the kinetic energy of the piston, an increase in the potential energy of the piston, and as work done against friction. In Dr. Cannon's equation, the term $P'(V_2 - V_1)$, which is supposed to represent the work done by the gas against the "opposing pressure," is in reality the increase in potential energy of the piston $M(x_2 - x_1)$, since $P' = M/A$.

There are two sources of irreversibility in this process: (1) friction between the walls of the cylinder and the piston; (2) pressure gradient that occurs in the gas when the piston is in motion. Even though both irreversibilities are assumed negligible in the given problem, Dr. Cannon still claims that the process is irreversible and that the irreversibility occurs at the piston face. Since, as noted above, the pressure of the gas on the piston must equal the pressure of the piston on the gas, I do not know to what "irreversibility" Dr. Cannon refers.

A system undergoes a reversible process if it can be returned to its original state without leaving more than a vanishingly small change in the surroundings. The system in question would seem to be reversible; it can be returned to its original state (if the cylinder is tall enough) merely by allowing the piston to rise and then fall again to its original level, recompressing the gas.

ROBERT A. GRAFF
The City College
New York, N. Y.

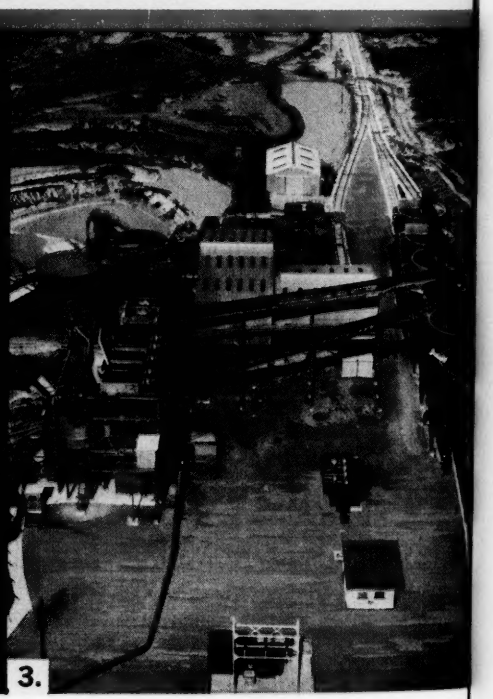
Sir:

Dr. Graff's comments are interesting and worthwhile.

In solving the first problem in my article, he develops a force equation and then converts it into an energy equation that is the exact equiva-

(Continued on page 168)

1. After separation from sand, phosphate moves along conveyor belts to storage bins to await shipping. 2. Phosphate maintains a backward flow while remaining sand is held to the center of these four parallel 60" belts, 80' long. Process is continuous, twenty-four hours a day, seven days a week. 3. Aerial view of Palmetto installation at Pierce, Florida.



At The American Agricultural Chemical Co.

ACME-HAMILTON NEOPRENE BELTS SEPARATE PHOSPHATE FROM SAND

Separating fine phosphate rock particles from sand is an extremely difficult job to ask of a belt conveyor. Ore is fed and slurried to a flat 5 foot wide conveyor belt with a flocculent of oil, caustic and water. The flocculent adheres to the phosphate, floating it off the sides of the belt while angular baffles continuously agitate the mixture, holding the sand in the center of the belt. Satisfactory belt service life is a serious obstacle in this operation. **Acme-Hamilton Neoprene Belts** with tough oil-resistant covers and a tensile rating in excess of 2500 pounds are presently in operation 24 hours a day, 7 days a week withstanding this severe duty imposed on them. The American Agricultural Chemical Company has been so impressed by the performance of these Neoprene Belts that they installed Acme-Hamilton Neoprene Belts throughout in their new Palmetto installation at Pierce, Florida. Write for information about this belt today. Dept. B-N

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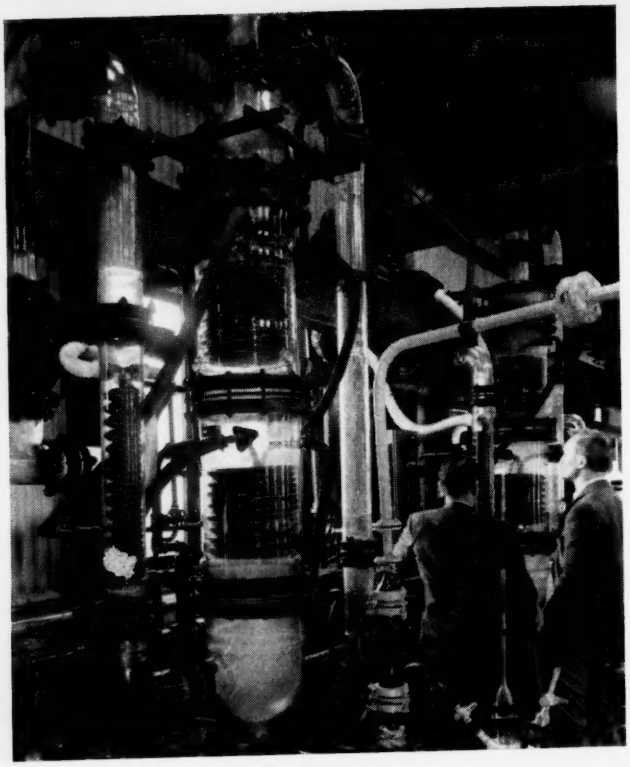

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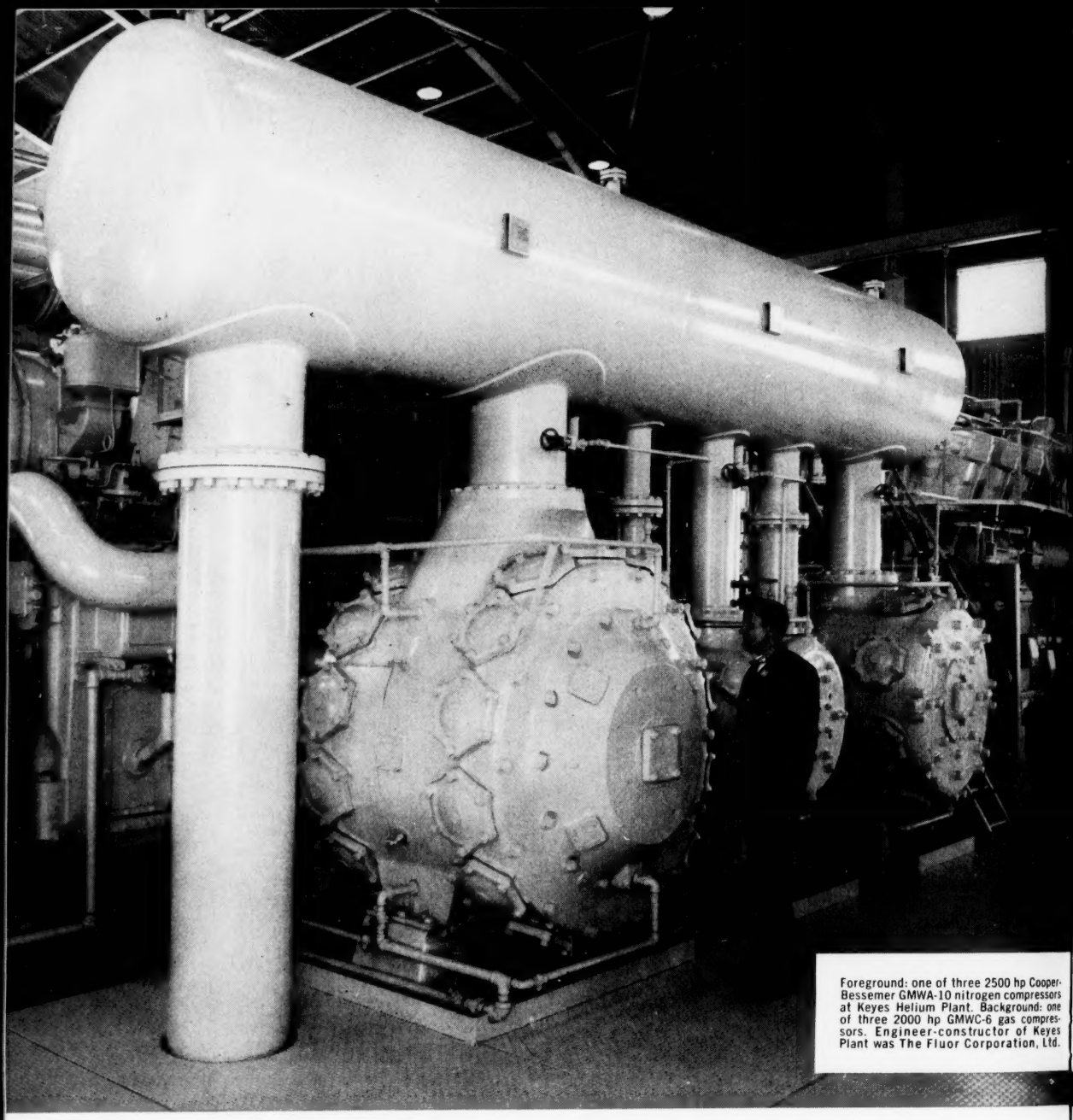

Foreground: one of three 2500 hp Cooper-Bessemer GMWA-10 nitrogen compressors at Keyes Helium Plant. Background: one of three 2000 hp GMWC-6 gas compressors. Engineer-constructor of Keyes Plant was The Fluor Corporation, Ltd.

Two 2000 h
gas compre
This plant a
pressors fo
constructor
was Stearns
For the 195
neer was St
Quaker Vall

How U.S.A. puts the squeeze on its helium

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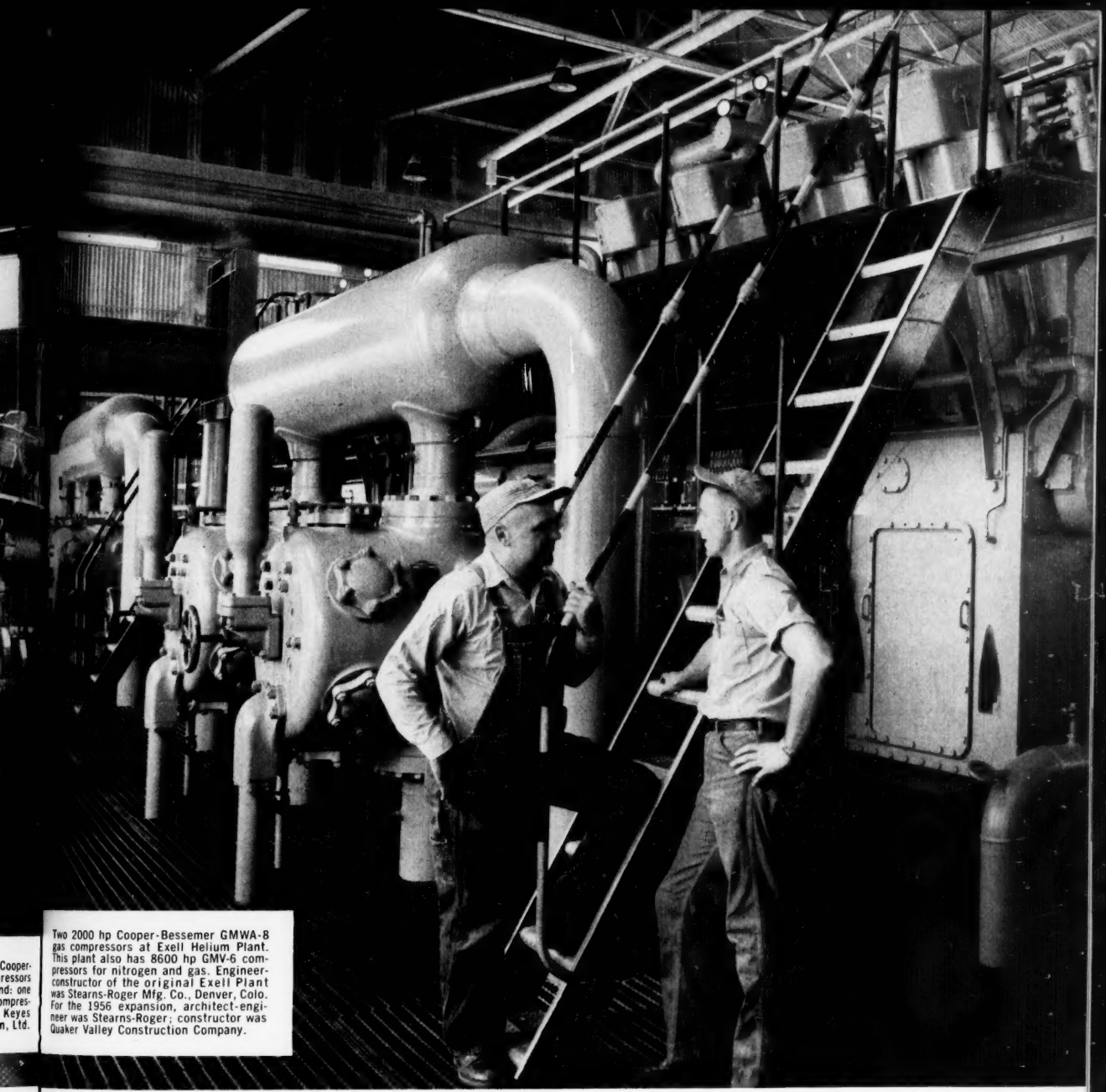

Two 2000 hp Cooper-Bessemer GMWA-8 gas compressors at Exell Helium Plant. This plant also has 8600 hp GMV-6 compressors for nitrogen and gas. Engineer-constructor of the original Exell Plant was Stearns-Roger Mfg. Co., Denver, Colo. For the 1956 expansion, architect-engineer was Stearns-Roger; constructor was Quaker Valley Construction Company.

The job of extracting helium from natural gas is a low-temperature process in which compression plays a key part. And that's where Cooper-Bessemer horsepower comes in . . . in a big way.

At our country's two principal existing helium plants—the Exell Plant near Amarillo, Texas, and the Keyes Plant at Keyes, Oklahoma—Cooper-Bessemer gas engine compressors play key parts in both of the basic, heavy-duty compression operations for helium extraction . . . compressing nitrogen for refrigeration and boosting pressure of natural gas for return to supply lines.

At Exell, built during World War II and expanded in 1956, ten C-B compressors total 8,800 hp.; at Keyes, completed in 1959, six total 13,500 hp. All of the Cooper-Bessemer units in both plants are giving reliable service, 'round-the-clock in the production of this highly important inert, lightweight gas for industry and the U. S. defense program.

Call our nearest office for information on C-B products for *your* compression and power facilities.

BRANCH OFFICES: Grove City • New York • Washington • Gloucester
Pittsburgh • Mount Vernon • Detroit • Chicago • Minneapolis • St. Louis
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SUBSIDIARIES AND DIVISIONS: Cooper-Bessemer International . . . New York
Cooper-Bessemer, S. A. . . . Chur, Switzerland • The Hague, Netherlands
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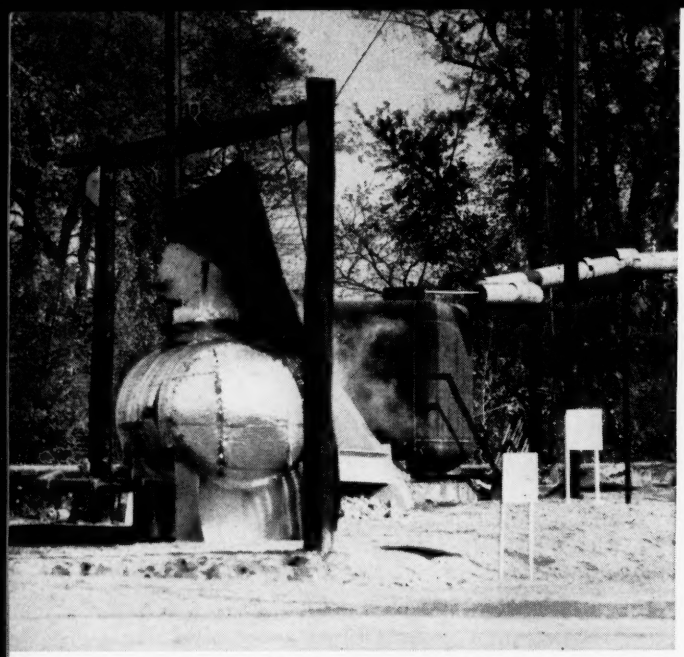
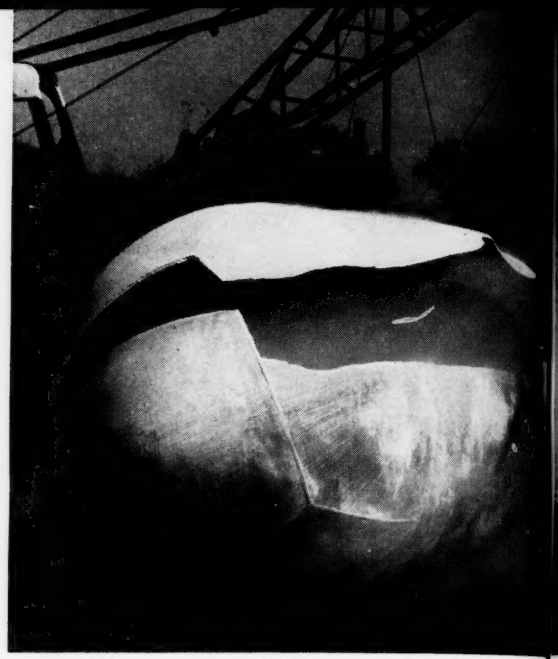
Cooper Bessemer

GENERAL OFFICES: MOUNT VERNON, OHIO

COMPRESSORS · RECIPROCATING AND CENTRIFUGAL
ENGINES · GAS · DIESEL · GAS-DIESEL
JET-POWERED GAS TURBINES



Burst-test for cylindrical-pressure vessels fabricated from USS 9% Nickel Steel, cooled to −320°F, then pressurized to bursting. This one was quenched and tempered—not stress relieved.



Same vessel after bursting at a pressure of 2,160 psi—almost 6 times the design pressure of 370 psi.

Operation Cryogenics—Success story of USS 9%

Destruction tests on welded tanks holding liquid nitrogen prove that vessels made from quenched and tempered or double normalized and tempered 9% Nickel Steel, *without* post-fabrication stress relieving, equal—and often exceed—the performance of vessels made of the same steel, which are stress relieved after fabrication.

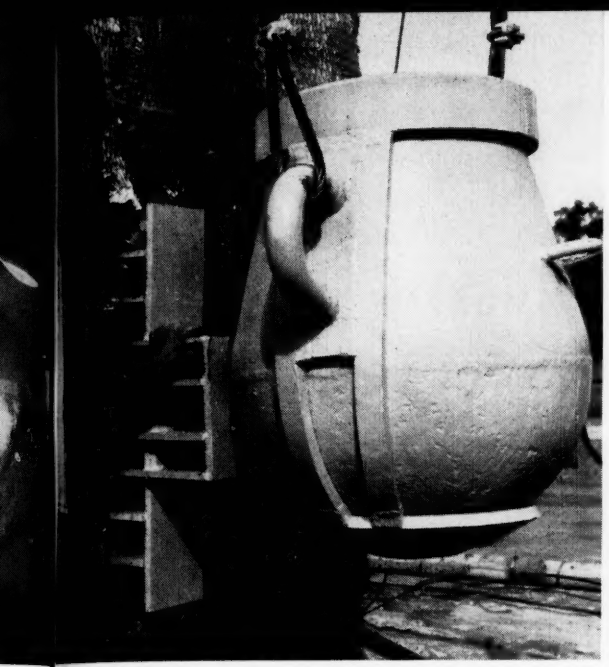
Recently, a series of impact and burst tests, known as "Operation Cryogenics," were performed on 9% Nickel Steel pressure vessels at the Fairless Works of United States Steel. The science of cryogenics, involving the development and practical utilization of materials in extremely low-temperature service, has assumed major importance in industry and in national defense. Much preliminary and advanced development work has been done cooperatively by The International Nickel Company, Inc., The Chicago Bridge & Iron Company, and United States Steel Corporation.

Objectives of "Operation Cryogenics" were to demonstrate (1) the suitability of 9% Nickel Steel, quenched and tempered or double normalized and tempered, in the as-welded condition (not stress relieved), for very low-temperature use; (2) the excellent properties of quenched and tempered 9% Nickel Steel; (3) the ductile behavior of 9% Nickel Steel in the as-welded condition during enforced failure at very low temperature; (4) the behavior of 9% Nickel Steel in the stress-relieved condition for very low-temperature use.

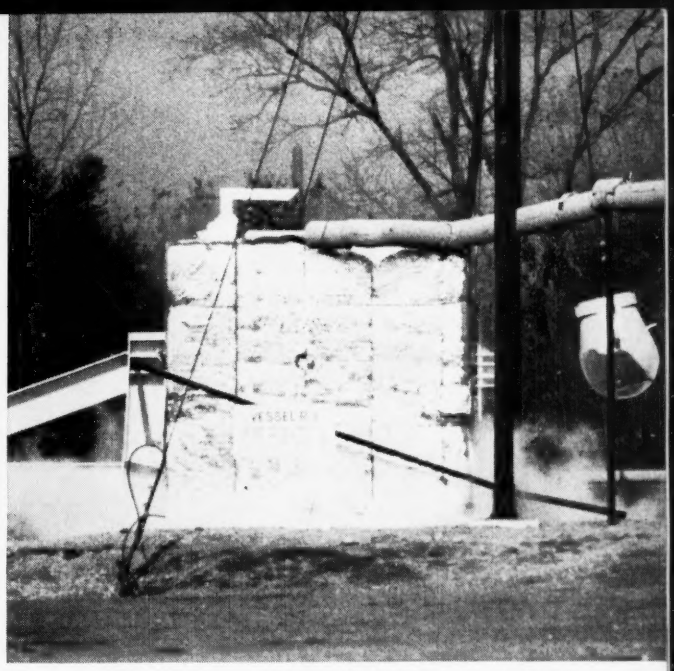
Test conditions: Two basic types of vessels were tested—rectangular vessels 8 feet square and 6 feet high, simulating a type that might be used for shipboard transportation of liquefied gases, and cylindrical vessels 4 feet in diameter and 13 feet long with hemispherical heads such as are used for land-based storage and transportation of liquefied gases. All vessels were welded from economical 9% Nickel Steel plate $\frac{3}{8}$" thick, from the same heat of steel.

A total of nine vessels was built for the test. Five were made from 9% Nickel Steel plates and forgings in the quenched and tempered condition (QT) and four in the double normalized and tempered condition (NNT). Further, six of the vessels were tested as welded (AW), without any heat treatment after fabrication. Three were stress relieved (SR).

Impact test results. Impact testing of the three rectangular vessels, refrigerated with liquid nitrogen to −320°F, illustrated that 9% Nickel Steel vessels are capable of undergoing extensive plastic deformation even at extremely low temperatures. The vessels were repeatedly impacted both under pressure and without pressure by blows exceeding 80,000 foot-pounds. One quenched and tempered vessel did not fail, despite 7 impacts. Results clearly indicated the ability of quenched and tempered 9% Nickel Steel vessels in the as-welded condition (not stress relieved) to withstand impacts far beyond any which are likely to occur in service.



4340-pound wrecking ball used in striking rectangular vessels from varying heights.



Impact Test—Rectangular vessel of 9% Nickel Steel quenched and tempered but not stress relieved, refrigerated to —320°F. Withstood severe impact of 82,460 foot-pounds and did not fracture, proving superior strength and toughness of the steel.

9% Nickel Steel Tanks punished at -320°F.

Burst test results. The cylindrical vessels were designed for 370 psi internal pressure (hoop stress in shell equal to 23,750 psi). These vessels were refrigerated to -320°F with liquid nitrogen and pressurized to failure. *The burst pressure for all vessels was at least four times the design pressure of 370 psi and one of the non stress-relieved vessels didn't burst until 2,300 psi.* (See Table I)

These tests prove that USS 9% Nickel Steel has the high strength, toughness, and weldability needed for low-temperature pressure vessels.

We urge you to consider USS 9% Nickel Steel for economical low-temperature vessels. For the complete story, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

BURST TESTS 9% NICKEL STEEL CYLINDRICAL VESSELS

	PC-1	PC-2	PC-3	PC-4	C-5	PC-6
Heat Treatment	QT	NNT	QT	NNT	QT	NNT
Test Condition	AW	SR	SR	AW	AW	SR
Temp. of vessel (°F) at start of test	—308	—320	—320	—320	—320	—322
Temp. of vessel at failure (°F)	—304	—320	—311	—310	—302	—314
Burst pressure (psi)	2,275	1,550	2,125	2,300	2,160	2,100
Burst stress (psi)	135,510	92,920	129,800	135,730	132,500	129,100

TABLE I. Complete data are shown for burst testing of the cylindrical vessels. In each test, the vessel was filled with liquid nitrogen, supply valves were closed, and pumping continued to build up pressure to bursting point. The data show quenched and tempered (QT) or double normalized and tempered (NNT) vessels in the as-welded (AW) condition withstood greater burst pressures and stresses than did the stress-relieved (SR) vessels.

IMPACT TESTS 9% NICKEL STEEL RECTANGULAR VESSELS

	PR-1	PR-2	R-3
Heat Treatment	QT	NNT	QT
Test Condition	AW	AW	AW
Impact number	#9 of 11	#5 of 6	#7 of 7
Vessel Temp. (°F)	—293	—317	—308
Height of Drop, ft.	19	19	19
Kinetic energy of 4340 lb. weight (ft-lb)	82,460	82,460	82,460
Impact Velocity of 4340 lb. weight (fps)	35	35	35
Vessel pressure before Impact (PSI)	106	100	0
Total indentation after test (inches)	2.44	1.38	3.38

Table II. Data are shown only for the impacts which resulted in cracking or fracture of vessels PR-1 and PR-2. The two vessels were subjected to repetitive tests under increasingly severe impact and pressure conditions, leading up to the test which finally enforced failure. Additional impact tests were conducted on the failed vessels to determine further distortion and dimensional effects. For vessel R-3, which did not fail, data are shown only for the last impact.

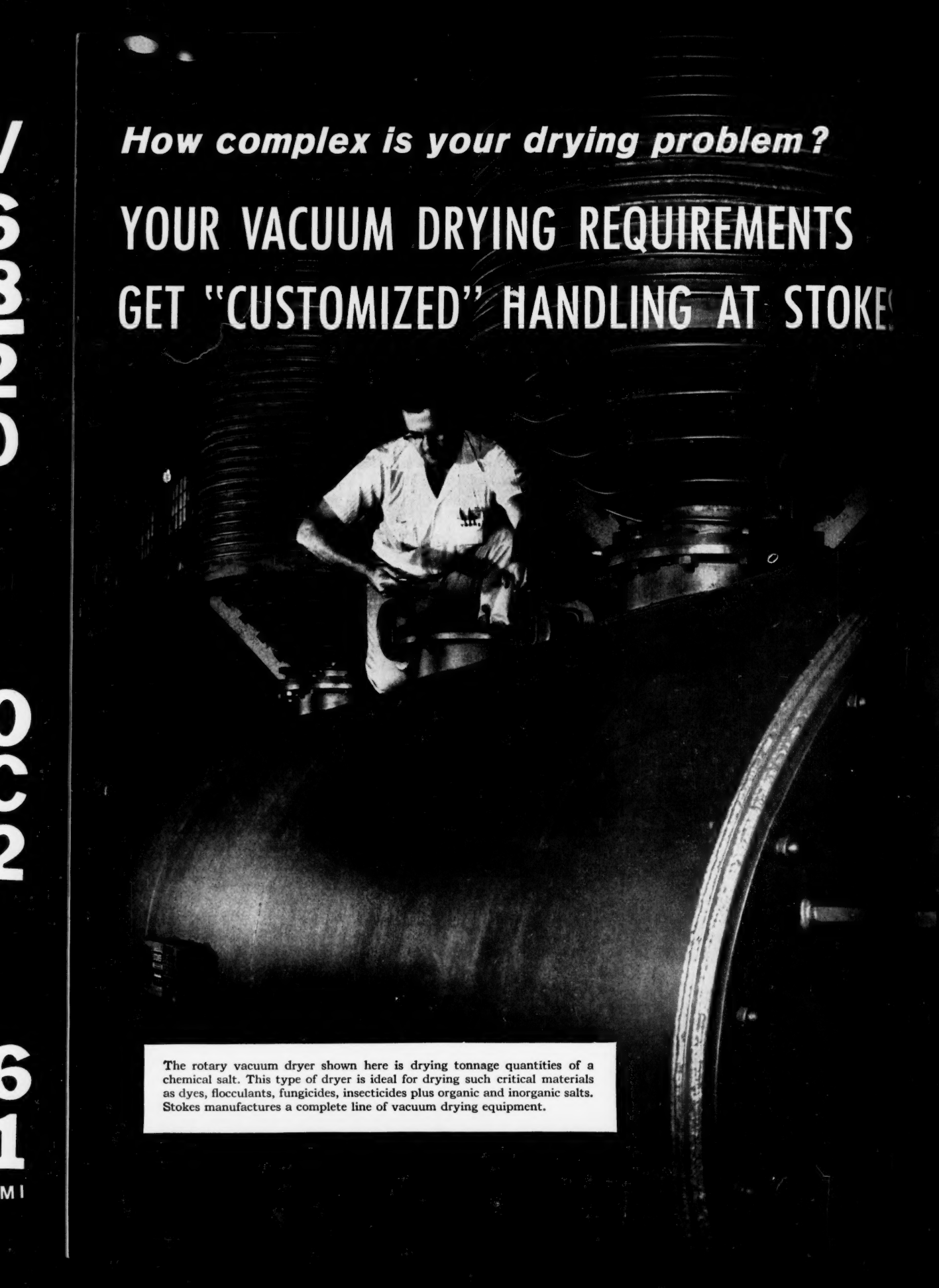
For *maximum* strength . . . toughness . . . safety

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
National Tube—Pittsburgh
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

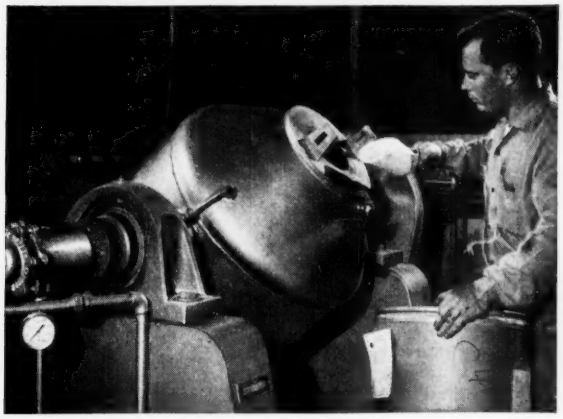
How complex is your drying problem?

YOUR VACUUM DRYING REQUIREMENTS GET "CUSTOMIZED" HANDLING AT STOKES



The rotary vacuum dryer shown here is drying tonnage quantities of a chemical salt. This type of dryer is ideal for drying such critical materials as dyes, flocculants, fungicides, insecticides plus organic and inorganic salts. Stokes manufactures a complete line of vacuum drying equipment.

Conical Vacuum Dryer shown below in Stokes laboratory is being used for a variety of tests on customer products.



PROCESSING tonnage quantities of materials in an inadequate vacuum dryer can be time consuming and costly. That's why Stokes experienced vacuum engineers study each drying requirement individually . . . then design the drying system to meet your specific needs. Drying systems in capacities from a few pounds to several tons are available . . . along with application engineering, laboratory service and pilot plant operations. Stokes puts its 50 years of vacuum processing experience to work on every drying problem . . . bringing you both money-saving and quality results. What's more, Stokes manufactures all its own pumps and accessories to assure you one-manufacturer responsibility in addition to unparalleled vacuum know-how.

Stokes will thoroughly explore your production problems . . . make recommendations on the basis of a practical knowledge of process operations . . . and confirm the recommended equipment by actual pilot plant production in the Stokes laboratory, if necessary.

WRITE FOR HANDY GUIDE

New booklet gives important hints on vacuum dryer selection. It describes briefly shelf, cone and rotary dryers . . . their construction, their operation and different types of applications. Our representative in your area will be glad to discuss your drying problems with you and make detailed recommendations. Check CEC for his address and telephone number.

STOKES

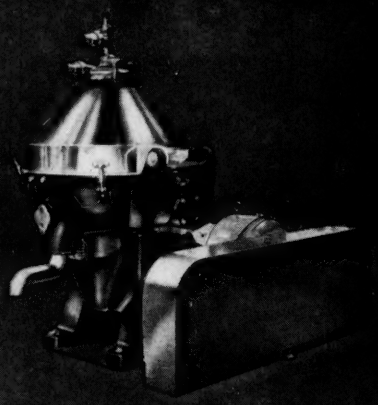
Processing Equipment Division

F. J. STOKES CORPORATION

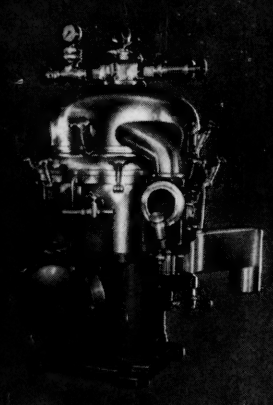
5500 Tabor Road, Philadelphia 20, Pa.

STOKES INTERNATIONAL: PHILADELPHIA • TORONTO • LONDON

Centrifugal Spin and 3-D Bounce aid solids separation and classification in DE LAVAL SEPARATORS



SOLIDS ARE CONTINUOUSLY REMOVED



A GREAT RANGE OF SOLIDS

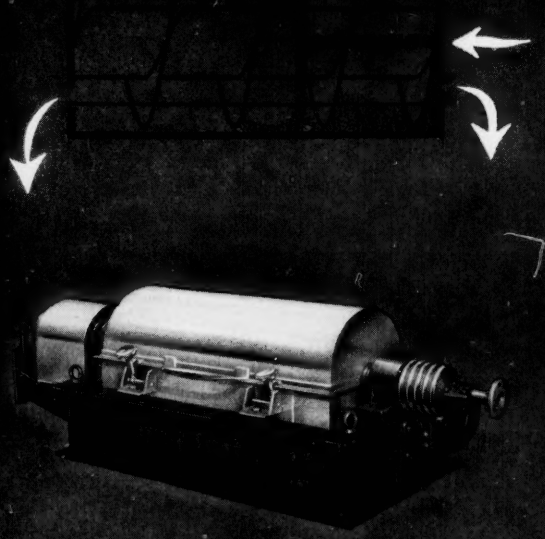
Solids separations problems ranging from clarification of murky liquids to solid classification are effectively solved by De Laval Process Equipment. These include special types of highly efficient disc-bowl centrifuges, conveyor-bowl centrifuges with high bulk-handling ability, and a unique type of classifying separator. Operation of these compact units opens new versatile possibilities in processing efficiencies and economies.

The Process Centrifuges described here are just a few from a complete line of industrial centrifugal separators. For full information on these, or the Syncro-Matic Separator, write us outlining your type of separation problem. Appropriate technical literature will be promptly sent.

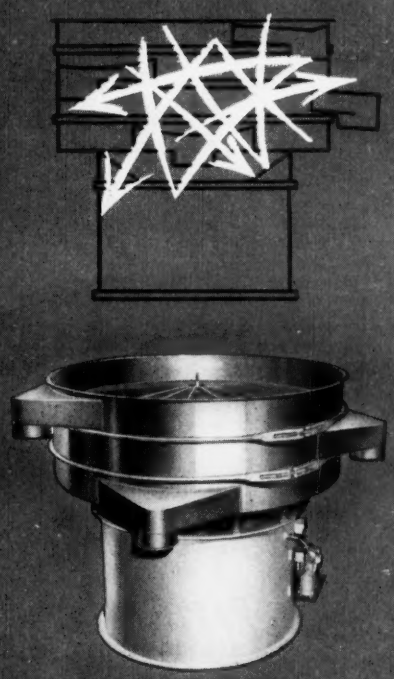
THE DE LAVAL SEPARATOR COMPANY

Poughkeepsie, N. Y.
5724 N. Pulaski, Chicago 46, Ill.
201 E. Millbrae Ave., Millbrae, Cal.

DE LAVAL



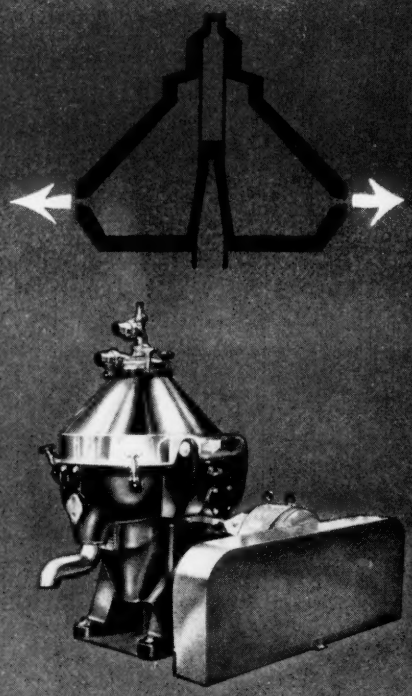
SLURRIES UP TO 50% SOLIDS



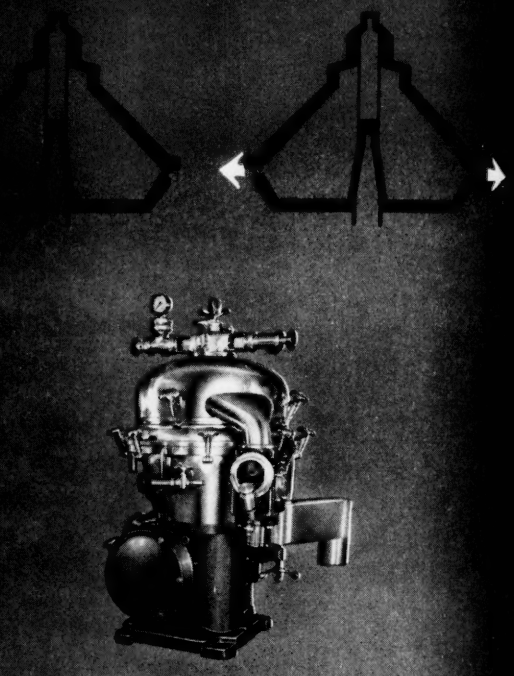
CONTROLLED 3-D BOUNCE SPEEDS SCREENING

...Crystals, powders, pellets or lumps—wet or dry—are kept hopping to a controlled frequency as they pass through the screen decks of the De Laval "Syncro-Matic" Separator. The direct drive mechanism permits easy adjustment to the 3-dimensional motion most suited to the product, ranging from gentle sifting to high-throughput classification. Uses range from scalping of liquid suspensions and thickening of slurries to efficient classification of dry materials. Screens are drum-tight and easily replaceable, screening motion is not dampened by loading—and a one horsepower motor delivers quiet, practically vibration-free performance.

Centrifugal Spin and 3-D Bounce aid solids separation and classification in DE LAVAL SEPARATORS



SOLIDS ARE CONTINUOUSLY REMOVED . . . at high capacities by the De Laval "Nozzle-Matic Centrifuge. Nozzles in the disc-bowl wall continually discharge the separated solids. Controlled recirculation of this slurry gives higher solids concentration with maximum recovery of liquid if desired. Feeds with up to 5% solids and flow rates to 18,000 gallons per hour are easily handled.



A GREAT RANGE OF SOLIDS . . are easily handled by the De Laval "PX" Self-opening Centrifuge. Crystalline, amorphous or fibrous solids are collected in a storage area along the bowl wall. At predetermined intervals, the special bottom and top bowl sections are separated, exposing slots through which the solids are discharged. Automatic discharge controls can be provided and capacities range to 6,000 gph.

With the "Nozzle-Matic" and the "PX Self-Opening" centrifuges can also provide normal separation of light-liquid phases independent of the solids-removal

Solids separations problems ranging from clarification of murky liquids to solid classification are effectively solved by De Laval Process Equipment. These include special types of highly efficient disc-bowl centrifuges, conveyor-bowl centrifuges with high bulk-handling ability, and a unique type of classifying separator. Operation of these compact units opens new versatile possibilities in processing efficiencies and economies.

The Process Centrifuges described here are just a few from a complete line of industrial centrifugal separators. For full information on these, or the Syncro-Matic Separator, write us outlining your type of separation problem. Appropriate technical literature will be promptly sent.

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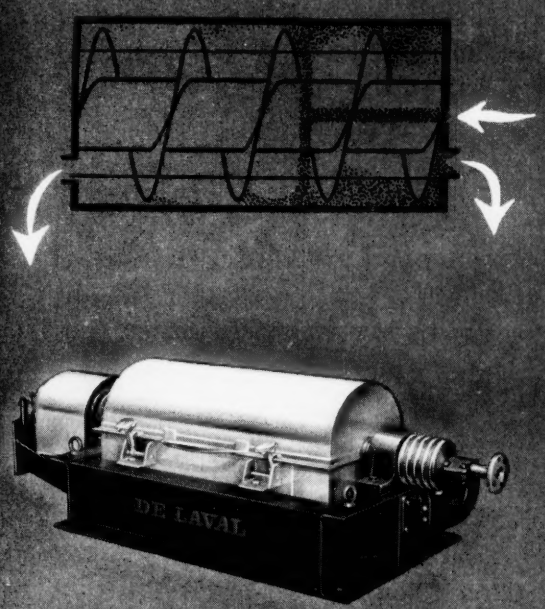
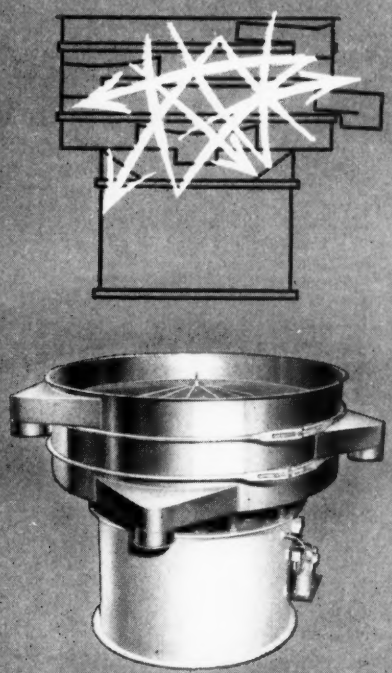
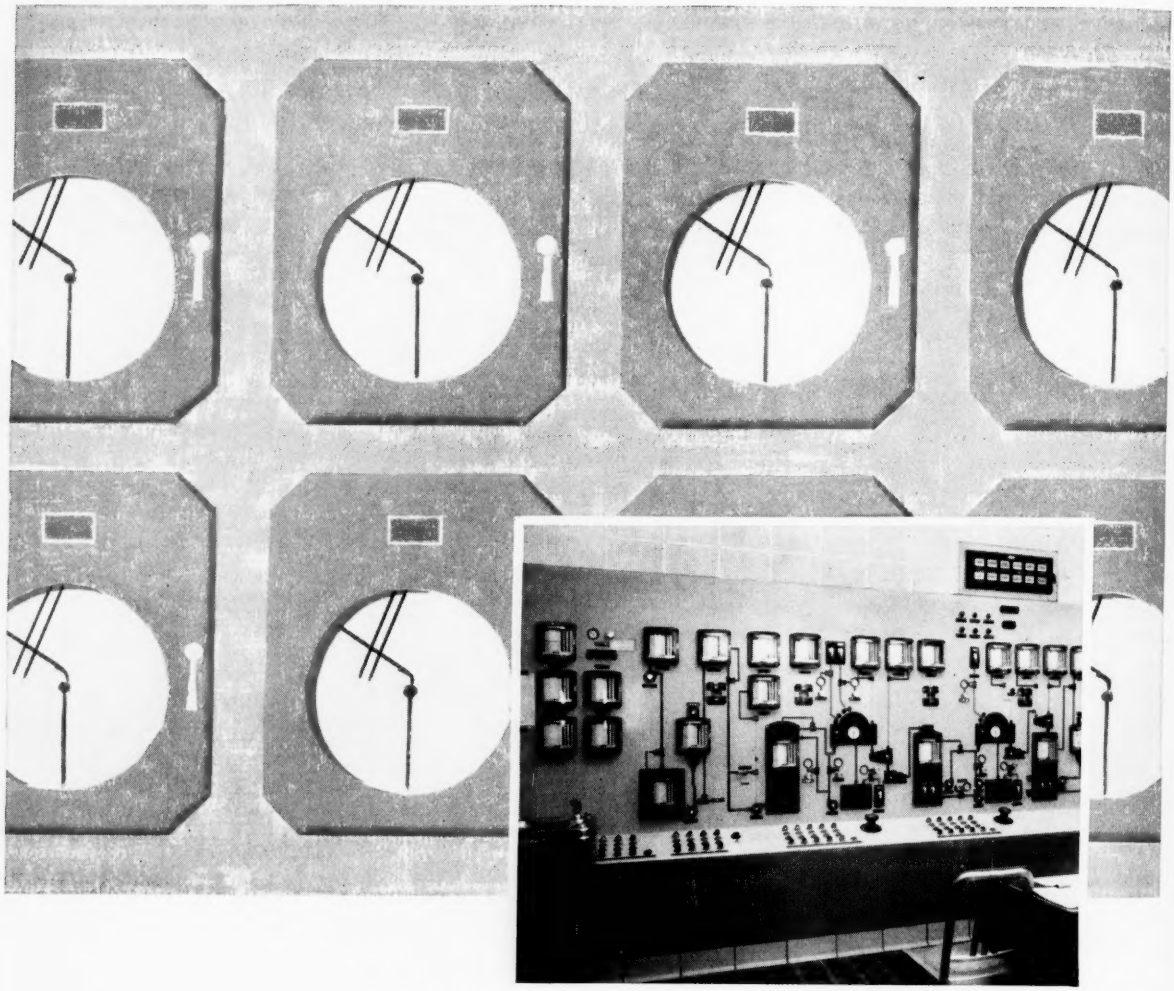


SLURRIES UP TO 50% SOLIDS... are processed by an ingenious horizontal centrifuge that applies 2000 G's of force to extract liquids and deliver solids to a desired degree of dryness. Solids thrown to the wall of the De Laval NX De-Sludger bowl are constantly conveyed by an internal screw for discharge at one end, while clarified liquid is removed from the other. High volumes of relatively dry solids can be recovered, while the liquid discharge is easily handled by a standard disc-bowl centrifuge if further clarification is desired.



CONTROLLED 3-D BOUNCE SPEEDS SCREENING ...Crystals, powders, pellets or lumps—wet or dry—are kept hopping to a controlled frequency as they pass through the screen decks of the De Laval "Syncro-Matic" Separator. The direct drive mechanism permits easy adjustment to the 3-dimensional motion most suited to the product, ranging from gentle sifting to high-throughput classification. Uses range from scalping of liquid suspensions and thickening of slurries to efficient classification of dry materials. Screens are drum-tight and easily replaceable, screening motion is not dampened by loading—and a one horsepower motor delivers quiet, practically vibration-free performance.

off with the OLD...



"MAG-PIPE" Magnetic Flowmeter Transmitter permits . . . . . .

- CENTRALIZED CONTROL ROOMS
- USE OF MINIATURE INSTRUMENTATION
- TRANSMISSION UP TO 10,000 FEET WITH 1/2% ACCURACY

Taylor Instruments

on with the NEW!

New Taylor "MAG-PIPE"* Magnetic Flowmeter Transmitter permits use of miniature instruments to $ave Panel $pace . . . and, for the first time, gives High-Accuracy Transmission over great distances . . .

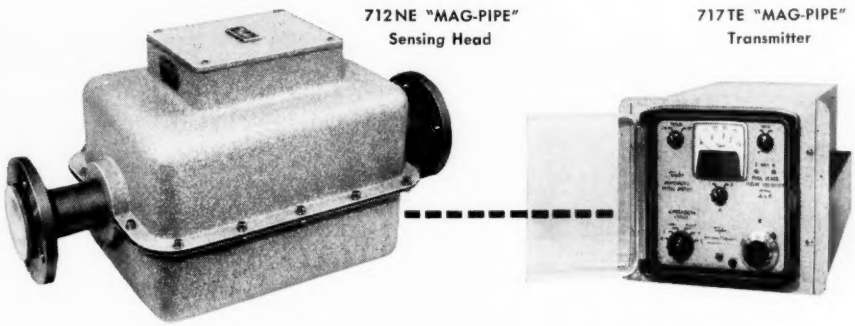
Not only does this outstanding new Taylor flow transmitter give you a very high degree of accuracy, it also permits conservation of panel space by use of miniature instruments, and transmission over greater distances. Designed to measure flow of fluids with an electrical conductivity as low as that of distilled water, it is ideally suited for very low flows, viscous liquids and liquids containing suspended solids. The flow is in no way restricted by the primary element.

The "MAG-PIPE" sensing head is mounted in the flow line. It comprises a flow pipe, an AC magnetic circuit and two electrodes. Sensing head housing is "hose-down proof" (explosion-proofing optional), and has lapped joint (Van Stone type) flanges for easier installation.

The transmitter employs solid state components, being fully transistorized for long-term reliability. It is standard in fixed-range form, in which case calibration is factory set at the desired range. Optionally available with a full-scale vernier adjustment and a 2-position range switch to measure any range between 1 and 30 ft./sec. A built-in output meter doubles as circuit checking device.

• • •

The "MAG-PIPE" Flowmeter Transmitter is in production. Consult with us on your difficult flow measurement problems. See your Taylor Field Engineer or write for **Bulletin 98418.** Taylor Instrument Companies, Rochester, N.Y., and Toronto, Ontario.



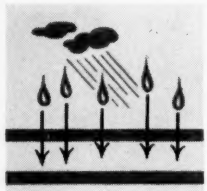
OUTSTANDING FEATURES

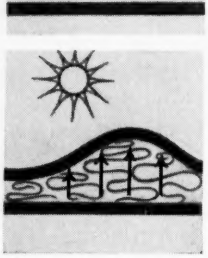
• High accuracy—one-half percent of full scale on most ranges • Full scale velocities as low as ½ ft./sec. at only slightly reduced accuracy • Conductivity range—as low as distilled water • Rangeability—½ to 30 ft./sec. full scale calibration, continuous vernier adjustment • Amplifier—solid state • Output signal—1-5 ma DC into any load from 0-3000 ohms. (Electro-Pneumatic Transducer or TRANSCOPE Electronic Control System).

*Trade-Mark

MEAN ACCURACY FIRST

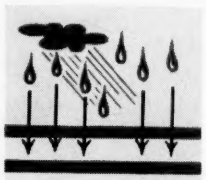
ROOF PERM ENDS ROOF FAILURE

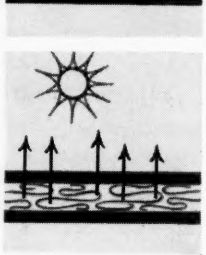




Other Roof Coatings Trap Water Vapor

During wet weather, all roofing materials absorb some moisture (upper left). When the sun comes out, this moisture attempts to escape as vapor. Ordinary roof coatings hold this vapor in (lower left) until the pressure reaches a point (sometimes as high as 90 pounds per square inch) where it breaks through the coating. The next rain pours more water into the roof, leading to more vapor build-up, more breaks, and ultimate roof disintegration.





New Lion Roof Perm Breathes Away Vapor

New Roof Perm not only holds out liquid water, as any good roofing material is supposed to do, but also allows trapped vapor to escape harmlessly (lower left). This is made possible by Roof Perm's exclusive breathing action. No roof-wrecking pressure builds up, and the coating remains intact and waterproof. Unlike emulsion-type coatings, which allow moisture to escape, but also to re-enter, Roof Perm remains resistant to moisture re-entry.

CAUSED BY TRAPPED WATER VAPOR

Now you can eliminate this main cause of roof failure, forever! Specify new Lion Nokorode Roof Perm, the first efficient breathing type, cold-applied roof coating ever developed.

Easy to Apply Cold

Roof Perm is solvent-thinned and easy to apply cold in any weather (usually by spray gun).

Weathering tests (details available) show that this product of Monsanto research simply has no equal as a permanent coating for new or old roofs.

Easy to Inspect

Because weather-resistant Roof Perm needs no gravel cover, it is easy for maintenance men to spot worn or damaged areas early, when repairs can be made inexpensively. Roof Perm will suffer less damage from normal building stresses than other roof coatings because it is designed to remain flexible and deform easily.

Write today for your free copy of Lion's new 65-page roofing manual, "Controlled Roofing Design and Maintenance," which gives details.

Also ask for complete information about our new flame-retardant roofing materials.

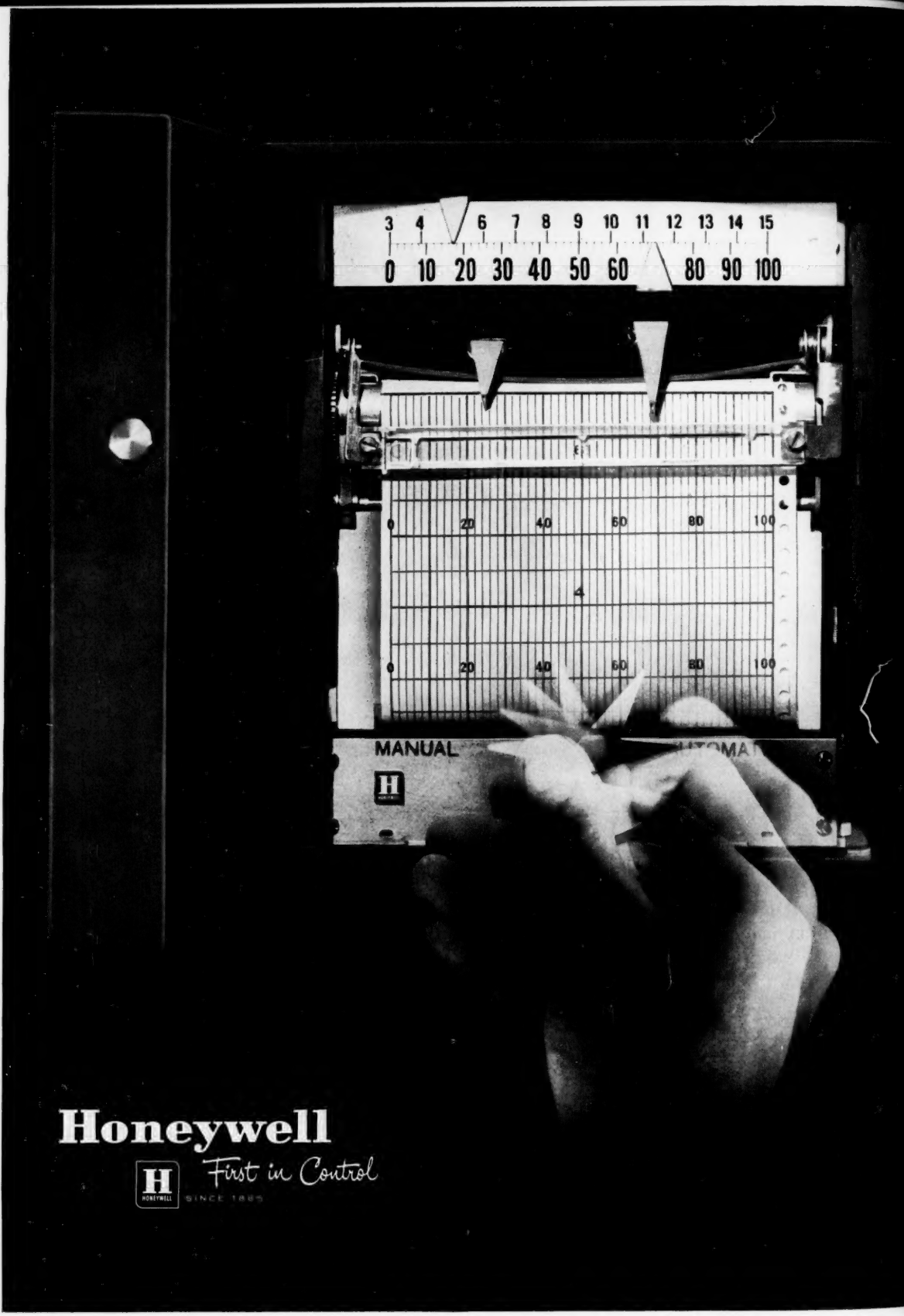
LION

Protective Coatings Department, Section 12

LION OIL COMPANY

A Division of Monsanto Chemical Company
EL DORADO, ARKANSAS

Monsanto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MANUAL
Honeywell
First in Control
SINCE 1885

Automatic Switching Eliminates Matching of Pressures *with*

New Honeywell PneumatiK Tel-O-Set Instrumentation

Honeywell brings new features, new performance to small case instruments with the introduction of *PneumatiK Tel-O-Set Instrumentation.* Here are just a few of the many new features:

Automatic Switching Just a flip of the control lever switches the instrument from automatic to manual or vice versa. There are no bumps, no delays, no matching of pressures required. This simplified switching makes cascade control systems practical for the operator.

Easily accessible adjustments Zero and damping adjustments to pen can be made while the pen is recording. Effects of adjustments can be seen *while* they are being made. Since it is not necessary to withdraw the recording chassis to make adjustments, there is no possibility of causing a pen zero shift.

Interchangeable chassis and controllers Recording and indicating chassis are interchangeable. Just pull out one chassis and plug in the other. Quick-connect air terminals eliminate the need for tubing connections. Two- and three-mode controllers with backset adjustments are also completely interchangeable.

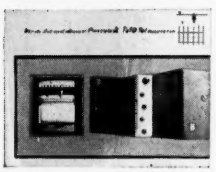
Easy-to-read, easy-to-change 4-inch charts Pen position on the 4-inch chart permits instantaneous reading of variables at all times. Pen arm design also permits rectilinear recording. Front-loading, tilt-out chart drive makes it easy to change chart rolls in a matter of minutes.

All cases fit 6 x 6 cutouts All models fit standard panel cutout of 6″ x 6″. Overall dimensions: 6¾″ wide; 7½″ high; 15¼″ deep.

Calibrated control adjustment Adjustments to controller can be easily made from back of the panel by removing controller cover. Calibrated dials for each adjustment ensure precise setting of proportional band, reset and rate values. Optional front-set control adjustments make it easy to set control from front of panel.

Easy to remove components To remove any particular component from the case, it is only necessary to loosen a screw or lift a latch.

HANDY DEMONSTRATOR-IN-PRINT Get the full story on new Honeywell *PneumatiK Tel-O-Set* Instrumentation by writing for this handy demonstration-in-print. This booklet covers in words and pictures all the important installation, operation and maintenance features of the new line. It will help you evaluate the many advantages *PneumatiK Tel-O-Set* holds for your process. Send for it today. MINNEAPOLIS-HONEYWELL. 4404 Wayne Avenue, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.



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IDEAS in chemistry from Norton

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Hydrogen for a variety of applications is available today from high temperature reactors lined with fused aluminum oxide refractory material. The requirement here is to contain the reaction . . . *containment without contamination*. Norton material meets the need. One important use of this hydrogen . . . which can be made anywhere . . . is in ammonia-base fertilizers for sub-marginal land.

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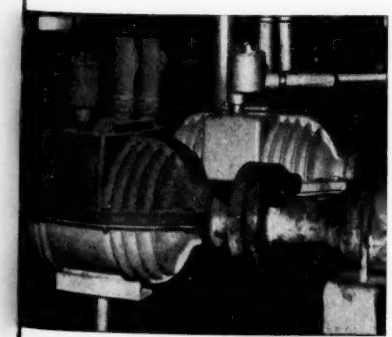
NORTON
REFRACTORIES

Crystallizing ideas into products

Foxboro Dynalog Electronic Recorder/Controller holds latex flow at exact preset value. Installation: Copolymer Rubber and Chemical Corp., Baton Rouge.

sticky, liquid latex...yet Foxboro meters it like water



Foxboro Magnetic Flow Meters, installed in feed line of synthetic rubber machines, meter viscous latex with an accuracy of ±½ of 1%. Note elbows before and after meter. Magnetic meters are unaffected by turbulence — do not require straightening vanes or meter runs.

It's Foxboro's famed Magnetic Flow Meter that does the trick — the meter with no flow restrictions. No orifice plates, no floats, no pressure taps — nothing to foul or plug up. Synthetic latex flows through meter unobstructed — electrodes "sense" flow rate, send a proportional electric signal to remote Foxboro Dynalog* Recorder/Controller.

Magnetic Meters seldom require maintenance. "We've had one operating continuously for 3 years and we've never even touched it," reports Copolymer Rubber and Chemical Corp. of Baton Rouge, La. Copolymer has 6 Magnetic Meters on their synthetic rubber machines — each metering with ±½ of 1% accuracy.

Got a sticky measuring problem? Perhaps the Foxboro Magnetic Flow Meter can solve it. Ask your nearby Foxboro Field Engineer for details. Or write for Bulletin 20-14. The Foxboro Company, 3610 Neponset Avenue, Foxboro, Mass.

**Reg. U.S. Pat. Off.*

FOXBORO

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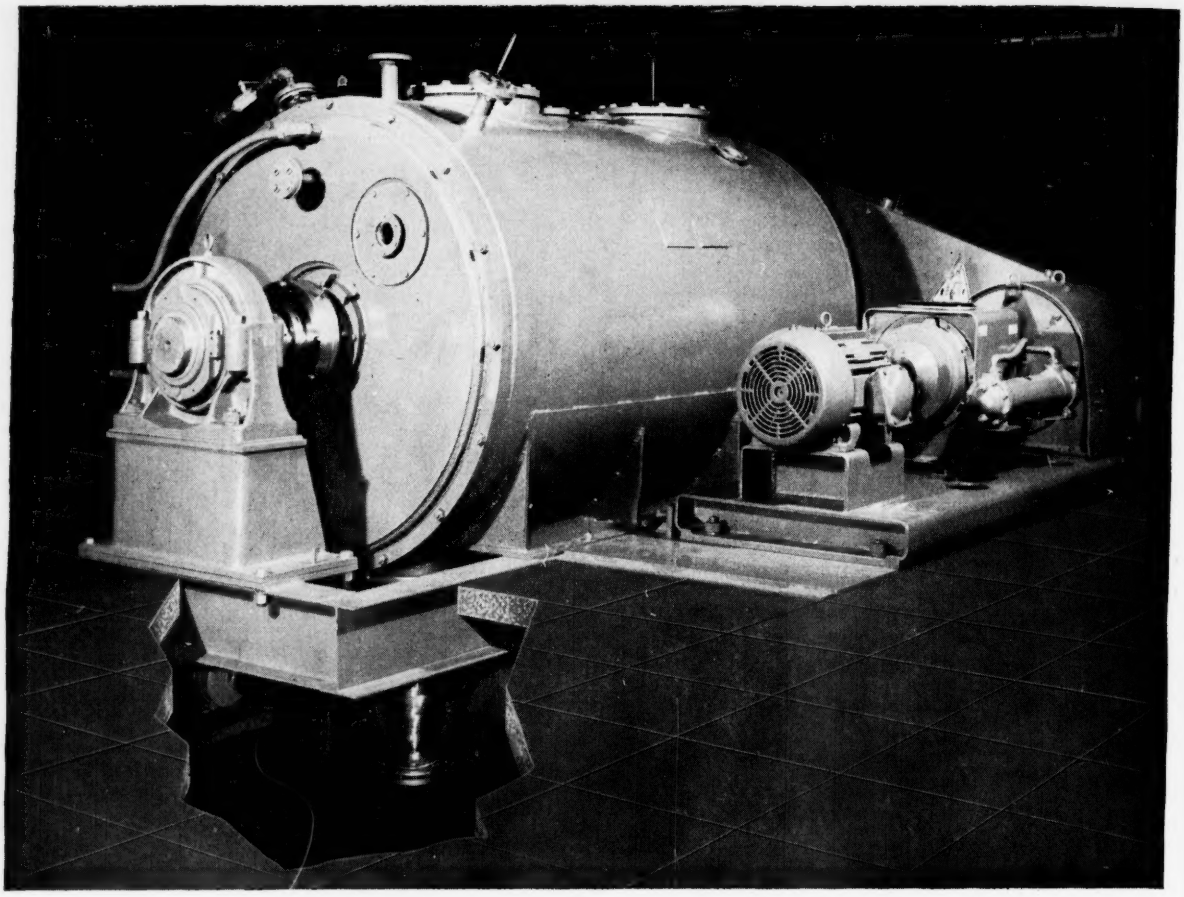
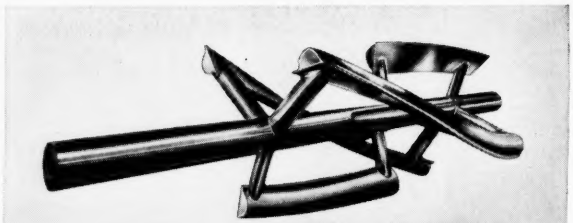


The DEVINE Rotary Vacuum Dryer
Sound Engineering—Precision Construction

The Devine Rotary Vacuum Dryer has long been established in the Process Industry around the world as a versatile drying tool.

The unit—designed for the quick, completely uniform and economical low-temperature drying of materials that may be turned over while drying—offers the perfect solution to countless drying processes.

The equipment pictured above was built to process streptomycin and will be installed in an antibiotic manufacturing plant being built abroad. This unit will operate at a pressure of 100 microns of mercury and with a leak rate of less than 1,000 microns per hr. with the rotor turning. It is equipped with flush-type discharge plug valve, sanitary jacketed nozzles for charging and discharging, Allison clutch drive, special double mechanical seals, jacketed end-plates and a rotor built entirely of hollow steam-heated No. 304 stainless steel, polished to a No. 4 finish. All these features, and many more, can be designed and engineered into the standard Devine Rotary Vacuum Dryer with each special feature aimed at further helping the customer to better solve his drying and mixing problem.



Stainless-steel steam-heated mixing element polished to a No. 4 finish for the above installation

With your next drying problem, or for that matter any processing equipment situation, call in J. P. Devine—where special engineering features are combined with creative design to give you the exact solution for your specific processing problem.

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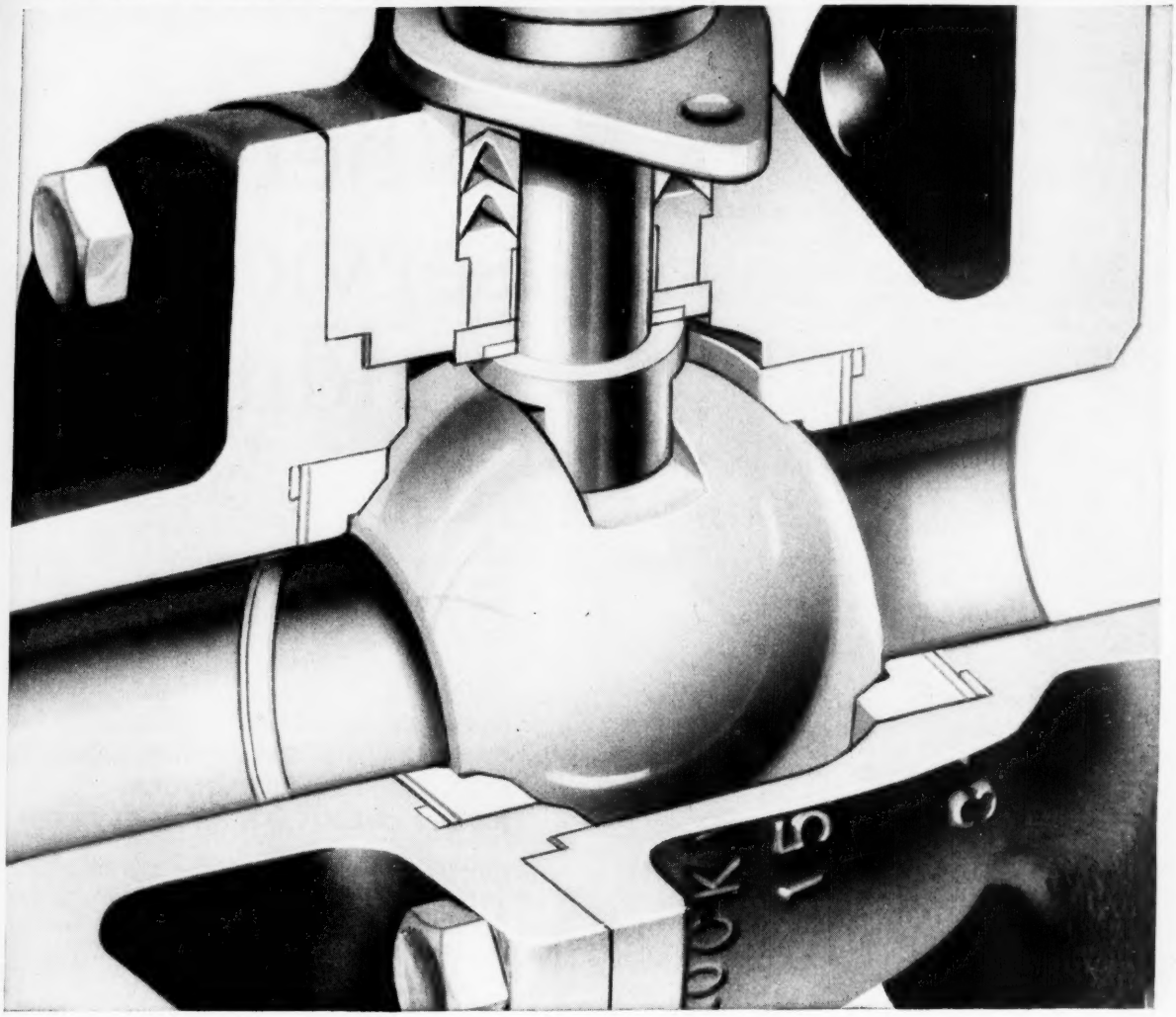
TAKE A CLOSE LOOK AT ROCKWOOD BALL VALVES



Where does experience come in?

Here are some factors to consider. Rockwood was the first to manufacture a commercial ball valve — with a design that has been time-proven in thousands of installations over the past 18 years. Rockwood is constantly making new refinements based on their solid "on-the-line" experience. Refinements such as *truly spring-loaded ball seats . . . rubber seats that seal tight* and stay tight through all conditions . . . *Teflon stem packing* to reduce wear — all intended to make quality better, service life longer.

And when you specify Rockwood Ball Valves, you get a wider choice of ball valve types and sizes.

Rockwood Ball Valves have these other important advantages too:

Ease of maintenance — no lubrication required; parts replaceable with ordinary tools.

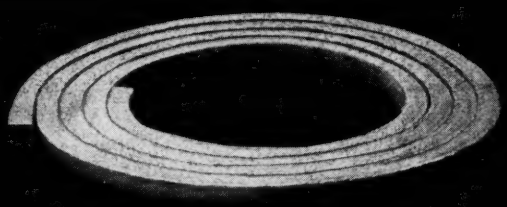
Larger waterway diameters for smoother flow.

Durability — built to withstand rough handling during installation . . . long, hard usage afterward.

Get the complete details from your Rockwood man, or write Rockwood Sprinkler Company, Ball Valve Department, 276 Harlow Street, Worcester 5, Mass. Distributors in all principal industrial areas. Rockwood Sprinkler Company, A Division of The Gamewell Company, A Subsidiary of E. W. Bliss Company.

ROCKWOOD

BALL VALVES

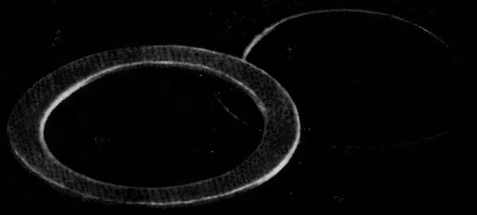


J-M CHEMPAC #2009 PACKING

This all-purpose packing provides low-friction sealing, effectively resists heat and chemicals. Asbestos yarns are braided solid, cannot ravel or come apart.

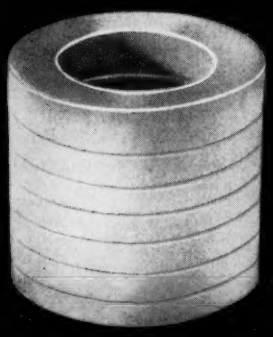
J-M CHEMPAC TEFLON ENVELOPE STYLE GASKETS

These gaskets have proved highly satisfactory in glass-lined equipment. The filler is protected against active chemicals and solvents by an envelope of pure Teflon.



J-M CHEMPAC SPIROTALLIC® FLANGE GASKETS

These highly resilient gaskets maintain a tight seal, and compensate for varying stresses and temperature changes.



J-M CHEMPAC V-RINGS

The unique design of these molded packings assures superior performance... low friction ... operational and dimensional stability.

Where service conditions are severe...

...JOHNS-MANVILLE CHEMPAC® PACKINGS AND GASKETS SEAL BETTER, LAST LONGER, RESIST CHEMICALS AND SOLVENTS

Chempac is the Johns-Manville trade name for a broad range of J-M materials which combine the excellent sealing and heat-resistant qualities of asbestos...with the immunity of Teflon* to almost all chemical and solvent action.

Because these J-M packings and gaskets provide such long, efficient and economical service, they are preferred by many producers of chemicals, petrochemicals, petroleum products, and foods. They also serve in critical missile and aircraft applications, in automobiles and in many electrical and electronic units.

If you need outstanding performance under virtually any severe service conditions, rely on J-M Chempac products. Your J-M Representative will be glad to help you select the correct style for your equipment and service requirements. Or, write to Johns-Manville, Box 359, New York 16, N.Y. In Canada: Port Credit, Ont.

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*DU PONT TRADEMARK FOR ITS TETRAFLUOROETHYLENE RESIN.

Top news stories and what they mean to CPI technical decision-makers

Chementator

Little increase seen in the cost of petrochemical feedstocks

There will be only a slight rise in the cost of crude oil and natural gas in the U.S. in the next decade. This opinion, which is good news to petrochemical producers, was voiced by B. C. Netschert of National Economic Research Associates at the recent AIChE meeting in Lake Placid, New York.

Netschert believes that oil and gas prices will creep up only a few per cent in the next ten years—assuming that the government continues the same degree of protection for the domestic oil industry. The often-heard argument that increasing costs of exploration will necessitate an increase in oil and gas prices will be offset by advances in technology that will tend to keep production costs at a constant level, Netschert states.

But if oil and gas prices climb higher, he notes, they will approach the break-even point of alternate sources of gas and liquids—coal and shale oil. With the present level of technology, this ceiling is about double the present cost of natural gas, and around 10% higher than the cost of liquid fuels derived from crude oil. Of course, technological breakthroughs are possible, which would make these alternate sources more competitive.

Prospects brighten for hydrate process of sea water desalination

One of the ways to extract fresh water from salt water is to form an organic hydrate from the feed, then decompose the hydrate to yield salt-free water.

This approach, the subject of bench-scale study by Koppers Co., Inc. (*Chem. Eng.*, Jan. 23, p. 86), received further research reinforcement at last week's Lake Placid AIChE meeting. A. J. Barduhn reported on basic investigations that Syracuse University has been conducting to find a more suitable organic working fluid for this type of system.

Koppers primarily has been using propane, which is inexpensive but requires 57 psig. and 35 F. for practical hydrate formation.

Syracuse, on the other hand, is looking for organics that form hydrates at conditions closer to ambient. Among the more promising to date are two of Du Pont's Freon fluorinated hydrocarbons—Freon 21 and Freon 31—and methyl bromide. The latter, for instance, forms its hydrate in sea water around 7.6 psig. and 58 F.

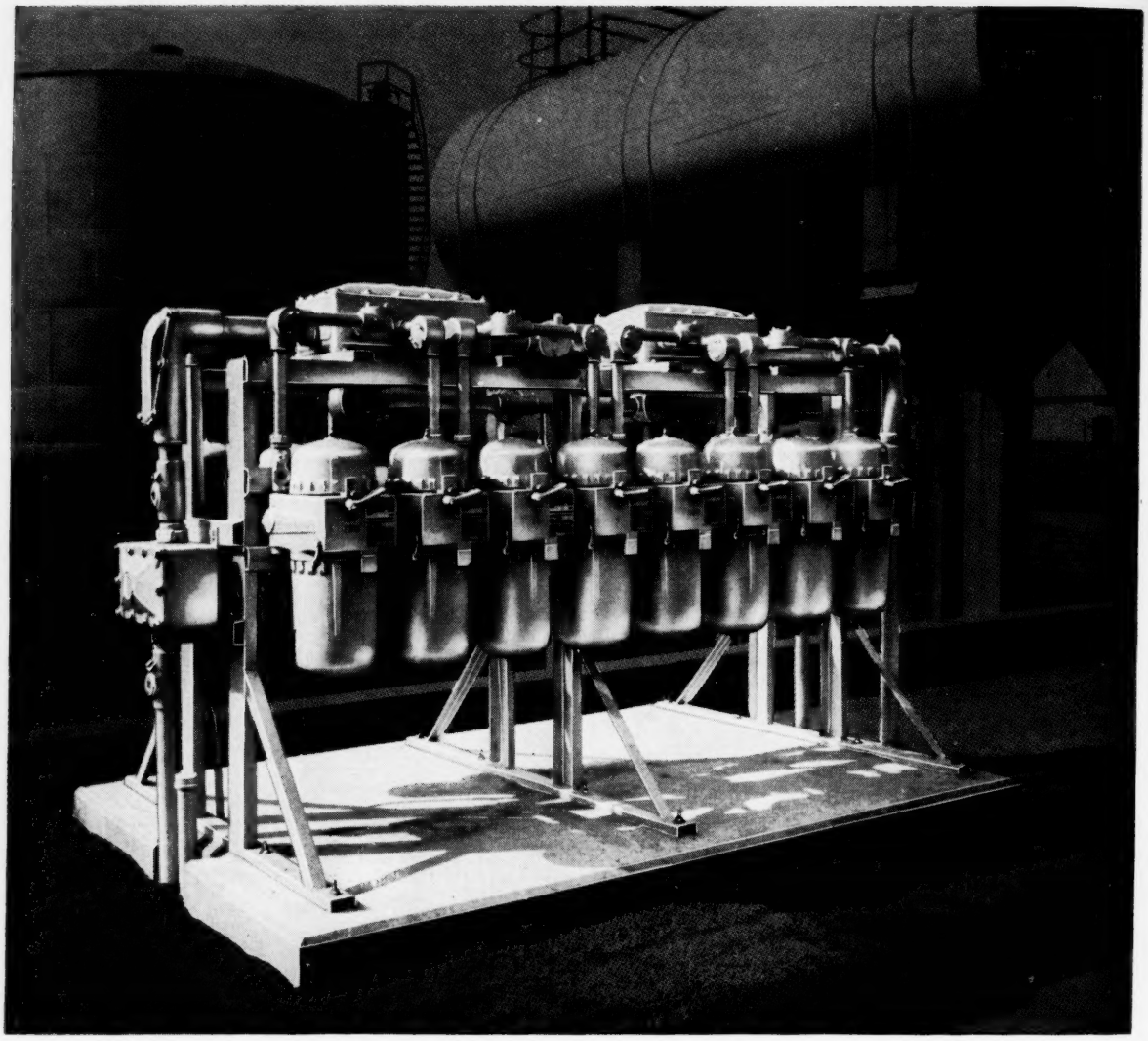
Big advantage that organic-hydrate systems offer is lower utility requirements for heat exchange and refrigeration. But, the compounds that Syracuse has found promising are more costly than propane. Because of inevitable process losses, this price difference would affect not only initial investment but also operating costs.

Syracuse's work (like Koppers') is under the auspices of the Interior Dept.'s Office of Saline Water. The university has no plans for actual desalting; its theoretical data are sent to OSW, where they are available as a basis for subsequent investigation by Koppers or other parties.

Exact cause of the SL-1 nuclear reactor disaster (Chem. Eng., July 10, p. 60) is still a mystery. Now that radiation levels are subsiding, investigators have discovered that the control rods had not been raised more than a safe amount—thus discrediting the widely held theory that the rods must have been withdrawn too far, starting a chain reaction.

Greatest hurricane damage to CPI plants came from water, not wind

Hurricane Carla, which smashed into Texas' Gulf Coast on Sept. 11, caused surprisingly little damage to chemical plants in the area, consider-



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Crouse-Hinds long experience in the design and construction of control racks insures safe, correct compliance with your specifications, from the simplest to the most complex.

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ing the savage intensity of the huge storm.

An unfortunate exception was Dow Chemical's plant at Freeport, Tex., which suffered losses amounting to $2 million, mainly from water damage. Levees in front of Dow's plant A (located nearest the coast) were high enough to withstand the storm, but a leak developed under the valves that control the flow of sea water to the Ethyl-Dow plant and water finally covered plant A to a depth of 5 ft.

At Dow's plant B, a towering wave of storm-blown water topped an 18-ft. levee and covered the plant with 4 ft. of water. Damaged mainly were instrument controls, motors, control laboratories and plant offices.

Just about all the chemical plants in the storm's path had gone through shutdown procedures provided for in the plants' disaster plans, and personnel had been entirely evacuated—or only skeleton crews left on duty. The long advance warning plus these shutdown precautions probably prevented more serious mishaps that might have resulted from power interruptions, motor failures, and short circuits.

The only other plants to suffer much damage were in the Texas City area. Both Union Carbide and Monsanto had flooding in their plants, but not of a serious nature. Both plants were back in at least partial production three days after the storm passed. Amoco Chemicals at Texas City had 4-5 ft. water in its plant, which caused considerable damage to electrical equipment.

There were no reports of damage to process equipment structures, even though gusts over 150 mph. were reported. One after-effect of the storm, however, may be a slowdown in construction projects in the area. Some contractors have expressed fear that it will take a long while to assemble construction crews again, since so many workers will be engaged in repairing damaged property.

High *cis* content looms as factor in making all-polybutadiene tires

Developments in polybutadiene rubber continue to pile up rapidly:

• This month Goodyear Tire & Rubber starts commercial production of polybutadiene at Beaumont, Tex., raising total U.S. capacity to over 75,000 long tons/yr. Goodyear shares this capacity about equally with Firestone and Phillips.

• Societe des Elastomeres de Synthese will build a 20,000-ton/yr. polybutadiene unit in France based on a licensing agreement signed with Shell, Goodrich-Gulf and Montecatini.

These developments sharpen the question of the significance of the *cis* isomer content in the polymer—and the effect that this may have on polybutadiene's role in the tire market.

Goodyear's polybutadiene, polymerized by a Ziegler-type catalyst, has 92% *cis* isomer. Company believes a *cis* content in the 90-96% range gives optimum processing and flow characteristics. But even though an all-polybutadiene tire will give about 90% more mileage than conventional treads, the company recommends blending polybutadiene 50-50 with SBR. The reason: pure polybutadiene is hard to process on conventional equipment.

On the other hand, Goodrich-Gulf claims it is the only company that can now produce a polybutadiene that can be used by itself in tire-tread stock. The Goodrich-Gulf product, to come out of a 20-million-lb./yr. plant now abuilding at Institute, W. Va., contains 98% *cis* isomer—via a cobalt-containing Ziegler-type catalyst.

Announcement of the new French plant stresses the high *cis* content of its intended product. Societe des Elastomeres notes that the only other polybutadiene capacity planned for France is a 20,000-ton plant that Firestone will build to produce the "ordinary" variety.

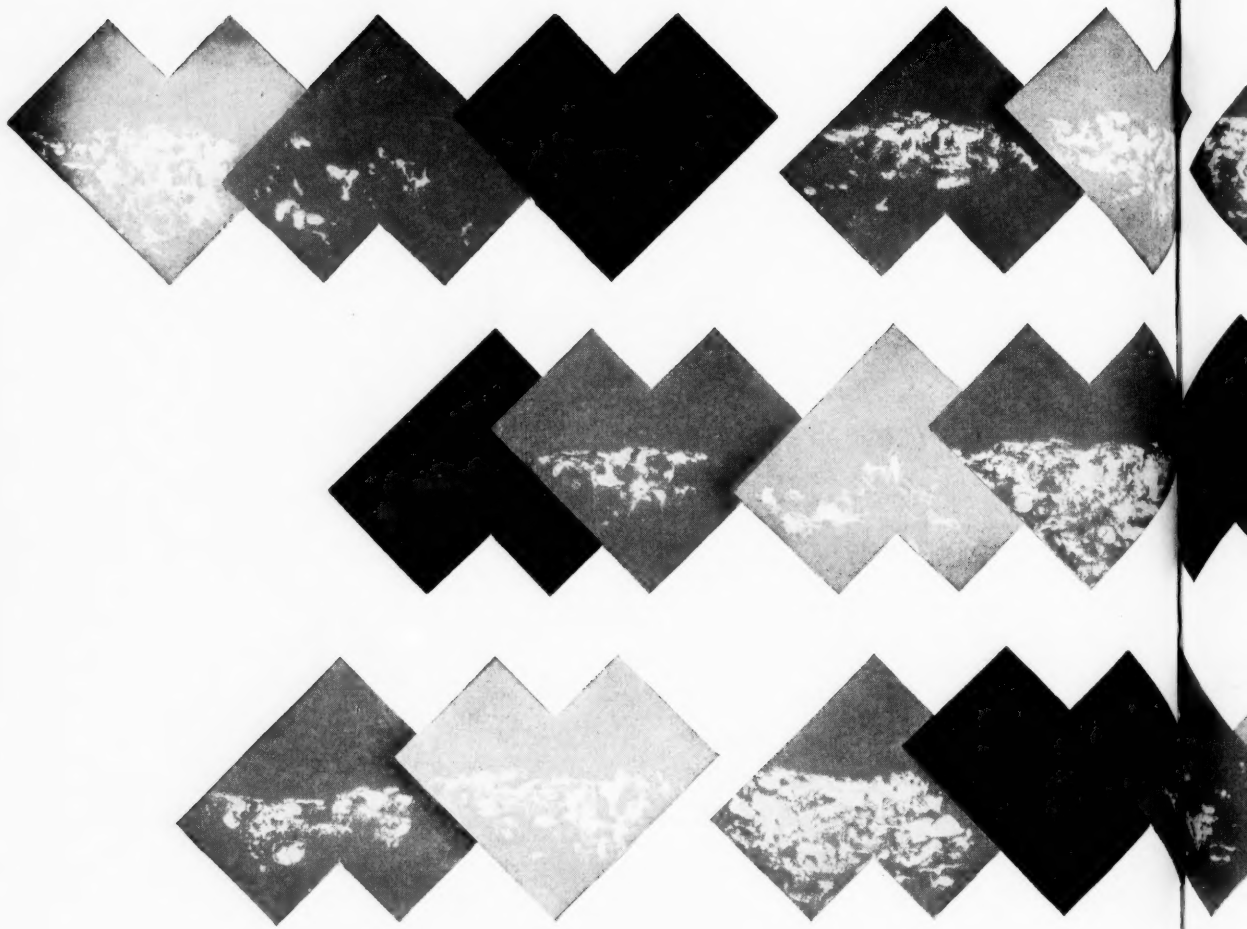
Firestone's commercial product, made with a lithium catalyst, is 35% *cis* isomer. Phillips', reportedly made with a titanium-containing catalyst, is 90% *cis*. Like Goodyear, these companies recommend that their product be used in blends.

Forecast for foams: overcapacity despite mushrooming markets

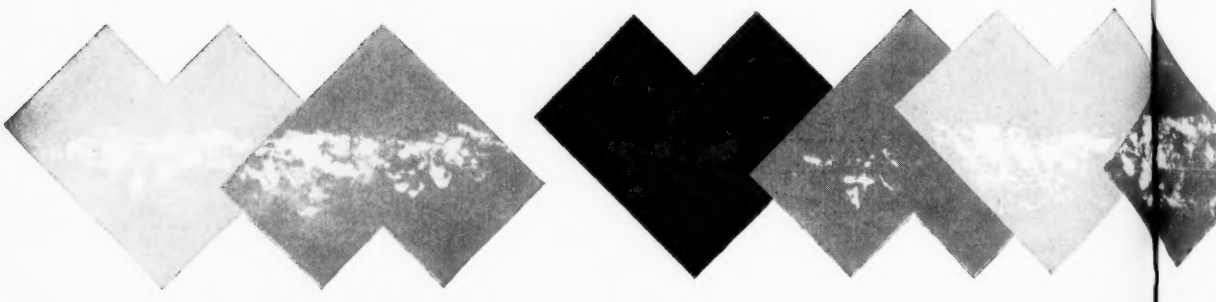
Projecting markets for organic foams at last week's meeting of the American Institute of Chemical Engineers in Lake Placid, Du Pont's John Tallman expects rubber's share of the market to dwindle from 230 million lb. to 200 million between 1961 and 1966, while the total market climbs from 426 million lb. to 820 million. Heaviest gainer will be polyurethanes, more than doubling 1961 production to reach 365 million lb. in 1966.

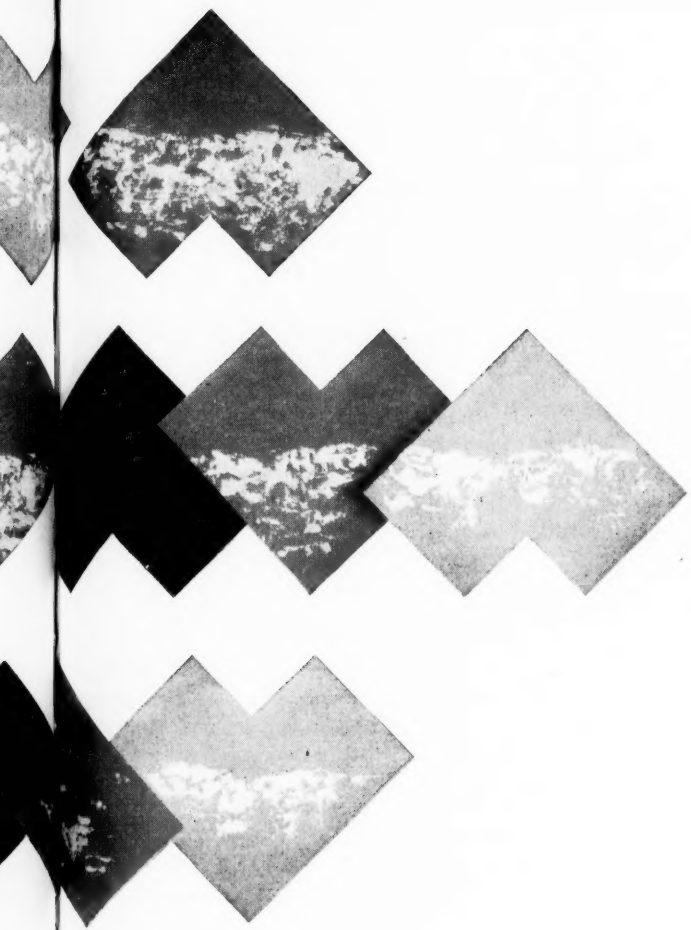
By then, total production of rigid foam will approach that of flexible foam. Now at 164 mil-

(Continued on page 38)

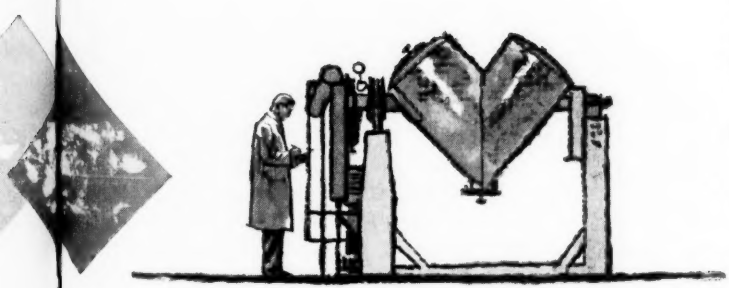


new P-K solids-processor* performs up to 10LID





to 10 LIDS PROCESSING OPERATIONS



1. *Gentle precision blending*
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4. *Granulation of solids*
5. *Vacuum drying of solids*
6. *Coating of solids*
7. *Heat sterilization of solids*
8. *Gas sterilization of solids*
9. *Chemical reaction of solids*
10. *Heating or cooling of solids*

(Many of these operations can be performed under vacuum)

The P-K Solids Processor offers new economies in quality control, equipment, time, manpower, space. For the first time it combines vacuum drying and liquid-solids blending in one fully packaged unit, performing more operations than ever before possible.

DRY BLENDING – With this latest P-K "Twin-Shell" development you can tumble solids to give gentle precision blending. This may be done under vacuum or atmospheric conditions, in inert or sterilizing gas, with heat in jacket up to 200°F., or with cooling through jacketed shell. If required, intensifier bar action breaks up agglomerates or gives uniform dispersion of difficult materials such as pigments.

LIQUID DISPERSION, GRANULATING – You can disperse controlled amounts of liquid uniformly into solids. Fluids of any viscosity can be handled.

Dispersion can be sufficiently intimate to provide a lump-free powder. Or you can regulate it to produce granulations of controlled size. As in dry blending, you can conduct these steps under vacuum or atmospheric conditions, in inert or sterilizing gas, or with cooling or heating through jacketed shell.

VACUUM DRYING – You can use the P-K Solids-Processor to vacuum dry heat sensitive materials. A separately actuated agitator speeds drying to a finished fine powder or controlled granule. In final stages of drying, direct hot air or gas can be introduced.

All P-K Solids-Processor systems are completely packaged. Available in standardized models with charge capacities from one to fifty cubic feet.

PRE-TEST SERVICES – A production model of the new Solids-Processor is available for pre-testing at our Pre-Test Laboratory in East Stroudsburg. Standard, intensifier and liquid-solids "Twin Shell" Blenders are also available . . . as are packaged vacuum tumble dryers (conical type) and ribbon blenders. Using your materials, P-K engineers can demonstrate things impossible to see without pilot study . . . work out subtle variables in blending, granulating, drying . . . indicate scale-up results and operational procedures . . . and predict savings in materials, labor, investment.

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Patterson Kelley

Chemical and Process Equipment Division
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lion lb. vs. a 262-million-lb. level for flexible foams, rigid's new output will be 395 million vs. 425 million for flexibles. In the long run, Tallman believes, rigids will be far the larger of the two. One big reason: the building industry, which will take 55 million lb. of polystyrene foam and 30 million lb. of rigid polyurethane in 1966. Long-range potential for foams in building insulation alone is over 1 billion lb./yr.

However, Tallman sounds a note increasingly familiar in the chemical process industry: "Productive capacities for some types of foams and their ingredients are greater than current markets. For example, installed capacity for producing flexible urethane foam in slab form is already greater than estimated consumption of these foams in 1966. . . . the detrimental effects of severe competition have been shown by erosion of the profits of most foam producers."

Besides the already-established polyurethanes and polystyrenes, there'll be new materials in the foam picture five years from now. Of these, rigid polyolefin foams will grow fastest: from 2 million to 35 million lb., mostly in wire coating. Polyvinyl chloride foam will go from 12 million to 55 million lb. New leather-like combinations of vinyl foam with fabrics or vinyl sheeting will account for 20 million lb., in auto upholstery, handbags and luggage. Rigid polyepoxies will go from 1 million to 20 million lb. Fluorocarbon-blown epoxy foams, having the same low thermal conductivity as the urethanes, are expected to take 10 million lb. of the low-temperature refrigeration market.

General Electric Co. has adapted its high-pressure synthesis process to the manufacture of semiconductor diamonds. They are made by adding impurities such as boron, beryllium or aluminum to the graphite and catalyst system, then subjecting the mixture to 1 million psi. and 2,000 F.

Additives give silicones status as high-temperature lubricants

The U. S. Naval Research Laboratory in Washington has developed additives for stabilizing silicone lubricants against oxidation and gelation, so that useful life at temperatures up to 600 F. is lengthened 30 to 500-fold.

The NRL inhibitors are metal-amine reaction products: iron, chromium, praseodymium, europium or cerium, in combination with disalicylal-ethylene-diamine or disalicylal-propylene-diamine. Cerium was found to give the best results, lengthening the period before gelation as much as 500 times.

Silicone liquids have found some use as lubricants in high-temperature applications, but have been limited by a tendency to gel above 400 F. However, their rare ability to retain desirable lubricating properties down to —65 F. has spurred intense research into extending their high-temperature service life.

The most effective silicone lubricants to date are the halogenated phenylmethylpolysiloxanes. High-temperature gelling can be reduced in these compounds by changes in the phenyl and methyl ratios, but this improvement sacrifices desirable low-temperature properties. The advantage of the new NRL inhibitors is that longer high-temperature life is obtained with lightly phenylated silicones that have desirable low-temperature properties.

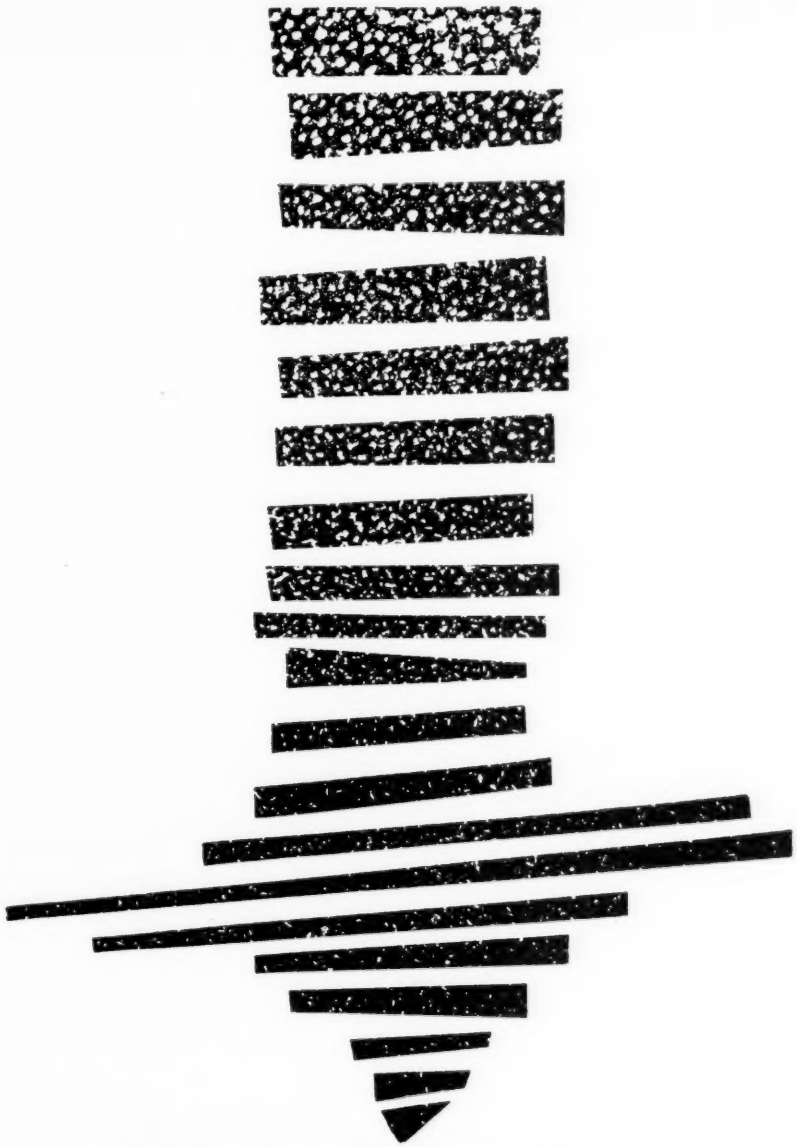
A report of this work, soon to be released, will be available through the Office of Technical Services, Business and Defense Services Administration, U. S. Dept. of Commerce, Washington, 25, D. C.

In what may be a prelude to a tougher attitude toward stream pollution (Chem. Eng., Aug. 21, p. 62), the Surgeon General has initiated federal action to clean up the North Platte River from Torrington, Wyo., to Broadwater, Neb. The pollution stems mainly from municipal sewage and sugar beet refineries in the area.

Firms vie for position as time nears for solid-fuel contracts

As the Air Force gets ready to award development contracts for the Nova solid-fuel rocket booster, the companies that hope to receive assignments are hastening to improve their positions. These maneuvers include a stepped-up rate of test firings (see p. 54) and corporate acquisitions.

An example of the latter is the recent purchase by Lockheed Aircraft of 100% interest in



exploring the Sub-Micronosphere

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Grand Central Rocket Co., a small solid-rocket firm. Lockheed acquired the firm in two stages from Petro-Tex Chemical Corp. (Petro-Tex is jointly owned by FMC Corp. and Tennessee Gas Transmission.)

One motive for Lockheed's move is the firm's belief that solid fuels, which account for only 25% of the propellant business today, will grab half of the market in a few years. And if solids successfully gain the big booster role, the ratio could shift to 75:25 in their favor.

Top priority for solid-fuel men is the 20-million-lb.-thrust Nova being developed in competition with Rocketdyne's F-1 liquid-fuel engine. By its move, Lockheed undoubtedly hopes to join other firms such as Aerojet-General, Thiokol, United Technology and Hercules Powder in development of the giant solid motors.

Present schedule calls for solid-fuel Nova development contracts to be signed this fall, with a final construction award probably being made next year when final specifications for the booster are written by the National Aeronautics & Space Administration. Actual flight tests will determine whether a solid-fueled booster or an F-1 cluster will loft the first Americans toward the moon.

Confirming earlier speculation (Chem. Eng., Sept. 18, p. 59), Enjay Chemical has become the first U. S. firm to make ethylene-propylene rubber on a commercial scale. Located at Baton Rouge, La., unit employs polymerization catalysts licensed from Karl Ziegler. Introductory price for the new elastomer is 26¢/lb.

Fuel-cell synopsis: interest high, progress slow, future uncertain

However slow the progress in producing a commercial fuel cell, there's no lack of interest in the effort, as evidenced by the overflow crowd that jammed the Symposium on Fuel Cells at Chicago's American Chemical Society meeting last month. Over 500 chemists and engineers sat through three crowded sessions, but heard no dramatic announcements that would indicate commercialization is near. Among the developments discussed:

• A methane fuel cell for home installation, operating at high pressure in the presence of steam, that reforms methane on the anode surface, producing a current by means of electrochemical oxidation of hydrogen.

• Paste electrolytes, made of powdered magnesia and molten carbonates (e.g., $LiNaCO_3$). They can be molded into any shape, making it possible to produce cells without gaskets that do not leak after two months' operation.

• A 200-w. power supply, based on an ion-exchange-membrane fuel cell, that operates on hydrogen and ambient air. Designed primarily for military purposes by the General Electric Co., it is currently undergoing testing for life and reliability. The 60-lb. unit contains 37 cells, measures 12 x 15 x 24 in. Hydrogen is generated on demand from the reaction of sodium borohydride and sulfuric acid, although high-pressure bottled hydrogen may also be used. One charge will operate the unit for seven hours.

• Still in preliminary stages of investigation are: an ammonia fuel-cell system; radiation activation of oxygen electrodes; double-skeleton diffusion electrodes for cathodic reduction of oxygen; and exploratory evaluation of fuel cells as reactors for producing chemicals.

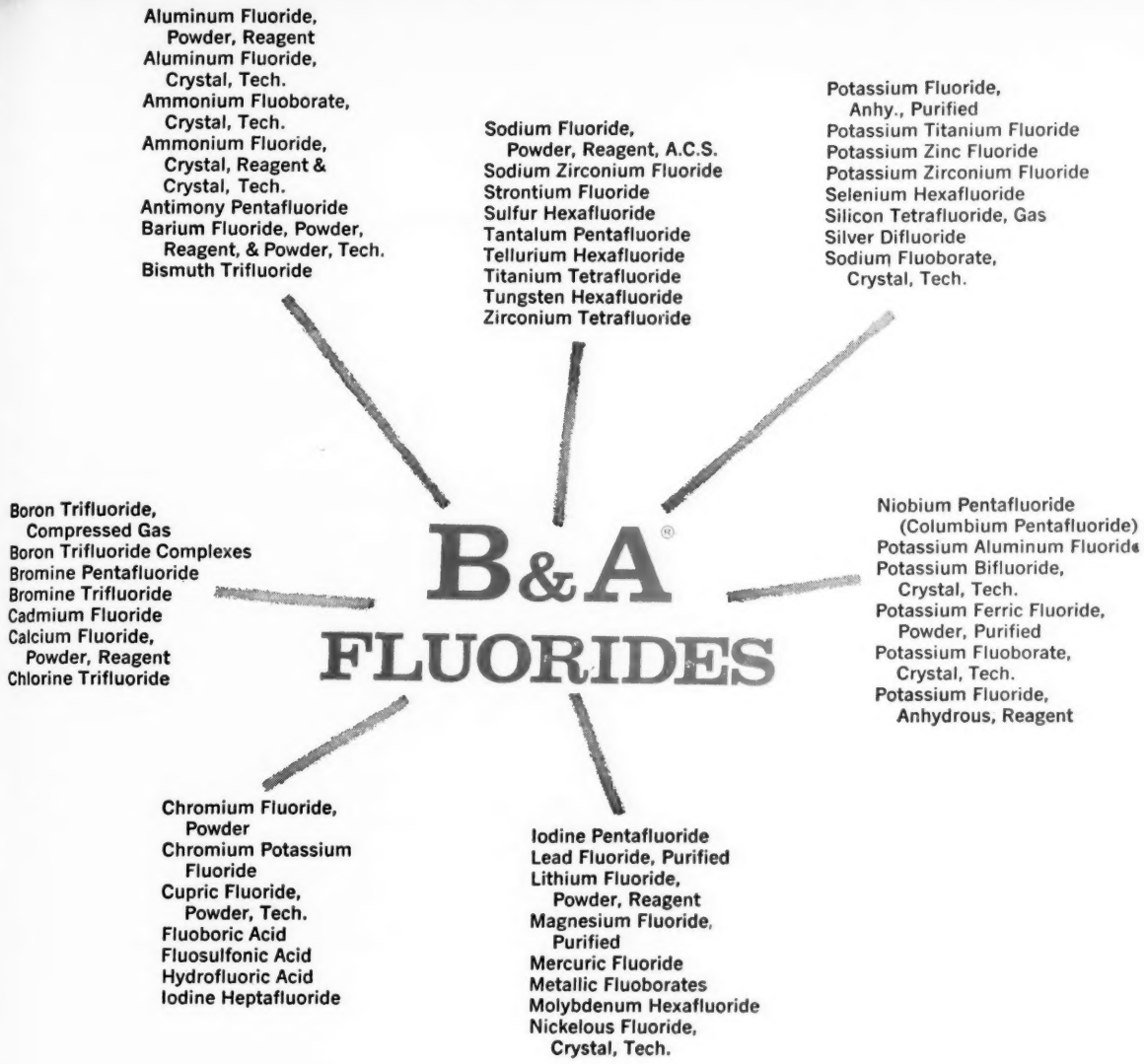
Petroleum companies get feet in the door of the nuclear business

Four petroleum companies are partners in a firm that is building a 500-ton/day uranium processing mill in the Shirley Basin area near Casper, Wyo. The four—Kerr-McGee Oil Industries, Skelly Oil Co., Getty Oil Co., and Tidewater Oil Co.—share ownership of Petrotomics Co., Los Angeles, which is developing uranium properties under a 5-yr. contract with the Atomic Energy Commission.

The mill will be one of the few new facilities to be erected since 1958, when the AEC announced that it would make no purchases from new discoveries of uranium ore. The acid-leach solvent-extraction plant should go on stream in April 1962, producing concentrates at a rate of about 665,000 lb./yr. Until the plant is completed, the company will sell about 500 tons of uranium ore from mine-development operations to the AEC for stockpiling or processing at other mills.

Petrotomics' contract expires in 1966, the latest date for which the AEC has contracted to purchase uranium from any domestic producer.

For More Industry & Economic News . . . p. 42



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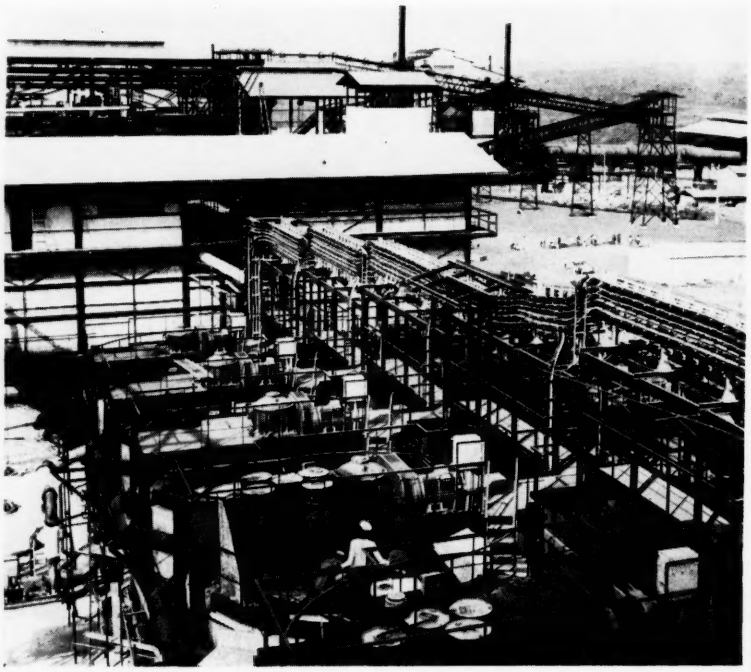
AFRICAN ALUMINA PLANT RESHAPES BAYER PROCESS TO OPTIMIZE PROFITS FROM LOW-GRADE ORE

Despite plentiful bauxite deposits and vast untapped hydroelectric potential, Africa gets its first alumina plant only after process revamping to compensate for lean ore, expensive soda ash and limestone.



FRIA's 480,000-metric-ton/yr. alumina plant is key unit in the $150 million, six-company bauxite mining complex now on stream in Guinea.

Africa's first output of alumina now is flowing from a plant at Fria, Guinea, that's designed to operate profitably despite some inherently high costs.

Some of these costs stem from the pioneering nature of the venture, which is backed by six corporations through share ownership in the operating company, FRIA Compagnie Internationale pour la Production de l'Alumine. Other costs are tied directly to the ore, a 200-million-metric ton deposit that averages only 42% alumina rather than the more-usual 50%, or better.

The incentive for economizing to make this project feasible came from rising world demand for aluminum, and Africa's position as one of the few places having vast bauxite deposits close to an enormous undeveloped hydroelectric potential.

▶ **Started With Mine**—In 1957, formation of FRIA started the commercial development of the Badi-Konkoure bauxite deposits, about 65 miles inland from the coastal capital city of Conakry. Mining from surface open pits got under way in 1959, followed by production of the first alumina in May 1960 from a 480,000-metric ton/yr. facility.

FRIA Ownership

Company	Percent Owned
Olin Mathieson Chemical Corp. (U. S.)	48.5%
Pechiney, and Ugine (France)	26.5
Aluminium Industrie Aktiengesellschaft (Switzerland)	10.0
The British Aluminium Co., Ltd. (Britain)	10.0
Vereinigte Aluminium-Werke A. G. (West Germany)	5.0
	100.0%

Total investment for the entire complex—including a 96-mile railroad between Conakry and Fria, plus installed silos, warehouses, port facilities, several hundred homes and social service buildings—was $150 million.

▶ **Close to Bauxite**—Location of the new plant adjacent to the bauxite deposit was a key factor in economic extraction of the ore, avoiding the high haulage charges per ton of recovered alumina inherent in the lean ore. But to maintain the advantage won by coupling plant to mine, the company had to incorporate many cost-shaving design features to offset the heavier sand and mud load introduced with 42% ore (see accompanying flowsheet). Still other expense-reducing tricks compensated for extra costs incurred in importing fuel oil, soda ash and limestone.

As yet, there is no nearby reduction plant to convert the alumina to metallic aluminum; so it is shipped to Edea in Cameroon, or to overseas smelters. Ultimately, a long-range project may get under way to carry out the immense earth-moving job needed to dam the Konkoure River so as to develop the hydroelectric potential for aluminum reduction.

▶ **Easy to Mine**—Bauxite deposits at Fria have essentially no over-

burden. Therefore, mining starts at the surface, with blasting by ammonium nitrate explosive in patterns arranged to fracture the ore down to less than 36-in. lumps. Trucked to the alumina plant, ore passes through a spiked-roll primary crusher for reduction to 15 in. A large secondary hammermill reduces size of pieces to 1-1.6 in. Up to two months' supply can be stored, half of it under cover.

▸**Unique Coarse Grind**—Crushed ore feeds into the process through 8-ft.-dia. × 12-ft.-long wet rod mills operating in open circuit to grind particles below 0.32 in. This relatively coarse grind is an essential cost-control feature; it is sufficient to insure efficient digestion, yet coarse enough so that 30-35% of the digestion residue can be removed and washed as sand in relatively compact rake classifiers.

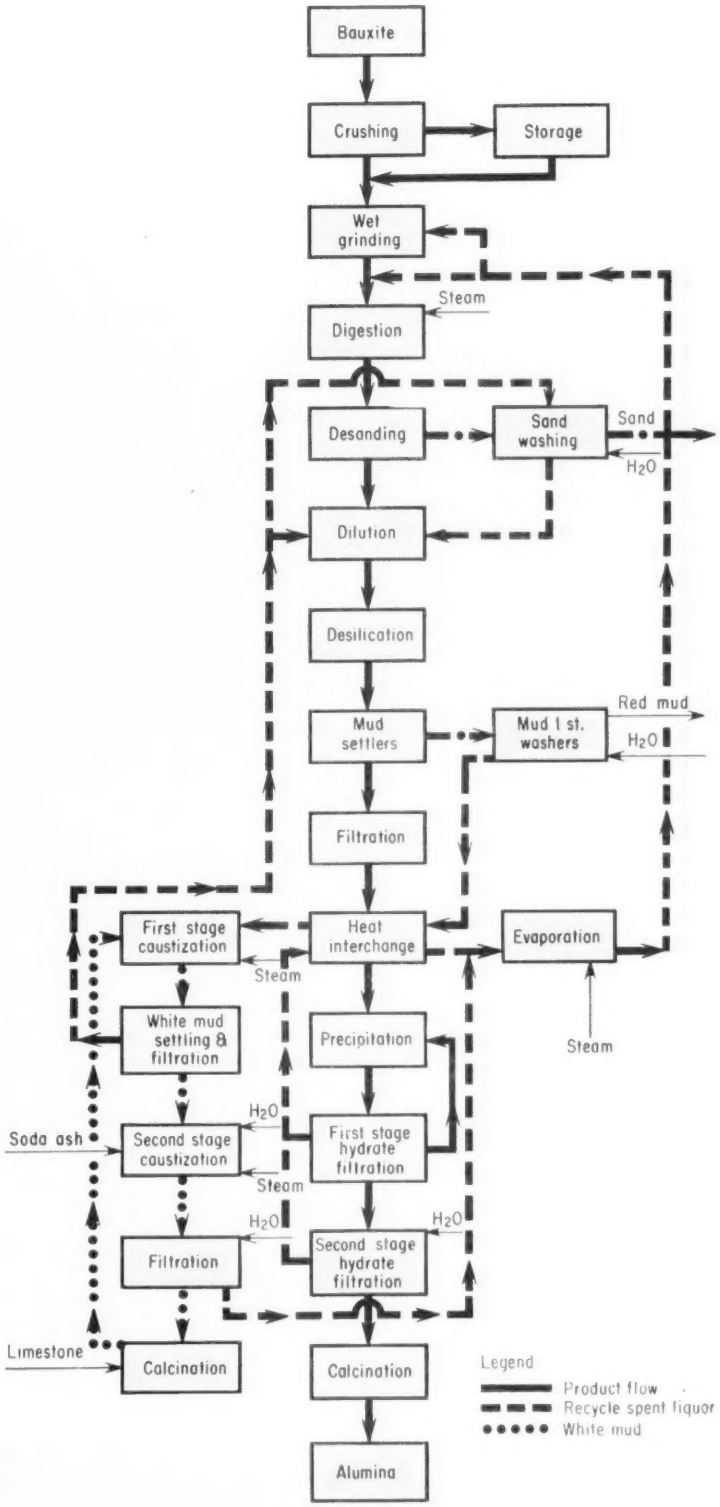
Discharging from the rod mills, the slurry flows into a tank where it is mixed with additional sodium aluminate liquor (200 grams/liter Na_2O). Out of the mixer, slurry passes into two parallel banks of eight atmospheric digesters 22 ft. in dia. × 20 ft. deep, where the alumina content of the ore is dissolved in the liquor at 220 F.

The low temperature and pressure are possible because of the readily soluble nature of the trihydrate ore. Furthermore, these moderate conditions minimize the amount of uncombined silica and quartz that dissolve.

▸**Giant Agitators** — Obviously, keeping ore solids sufficiently coarse to permit easy separation and washing of digestion residue places a severe demand on the agitation equipment. FRIA's ability to keep slurry, (consisting of 3.0-3.5 sp. gr. solids suspended in 1.35 sp. gr. liquor) uniformly suspended during digestion depends on the action of giant 8-ft.-dia., 70-hp. turbine agitators. Supplied by Denvers Equipment Co., these units operate inside draft tubes.

▸**Wash Sands**—Leaving the digesters, the slurry contains 1.5-1.6 tons of insoluble residue per ton of Al_2O_3. Passage through a hydroseparator drops out the coarse sand fraction, which is then washed

Cost cutting steps feature modified flowsheet



countercurrently in rake classifiers to recover alumina values.

Overflow from the hydroseparator, containing fine mud, is diluted with overflow from the primary causticizers and sand washer. Then it enters large agitated tanks to be held at 212 F. for 7-8 hr., for desilication of the liquor. Here the combined silica in the bauxite reacts with the sodium aluminate to form insoluble sodium aluminum silicate precipitate that becomes part of the residual mud from the desilicators.

▶ **Wash Fines**—After desilication, flocculent is added and the suspension is thickened. Primary thickener underflow goes to a five-stage series of countercurrent washing thickeners; overflow of relatively clear liquor passes through six 2,900-sq.-ft. leaf filters for final clarification.

The washing thickeners discharge mud to waste. Dilute sodium aluminate liquor overflow recycles to the causticization area.

The thickeners operate for maximum recovery of solubles so that expensive imported soda ash makeup can be minimized. These are single-deck units 100 ft. I.D. × 15.75 ft. high, with peripheral discharge through three openings 120 deg. apart.

Clear green-liquor filtrate from the leaf filters passes through plate heat exchangers for cooling to 123 F. against overflow from the second washer; then against spent aluminate liquor from the precipitators; finally against cooling tower water.

▶ **Seed and Harvest**—Next, seed alumina is added to the liquor, which then flows into two lines, each comprising 12 continuous precipitators 39.4 in. dia., and 112.5 ft. deep to the apex of the 60-deg. cone bottoms. During the 50-hr. retention, airlifts circulate the suspension through eight branches that discharge at top. Gravity flow carries the slurry from one precipitator to another.

At completion of precipitation, disk filters separate the alumina particles, which are relatively solid crystallites free of agglomerates and with 10% maximum plus-100 mesh, 33% maximum minus-325 mesh. One-sixth of these solids go to washing drum filters to be finished as product; the remaining five-sixths recycles back as seed to the precipitators.

Washed alumina feeds to rotary kilns 333 ft. long × 11.8 ft. in dia., for calcining at 2,200-2,300 F. Hot calcine passes through a fluidized cooler, which heats secondary air for the kiln. A water cooler completes the job.

▶ **Handling Losses**—As compensation for the soda lost with the insoluble desilication precipitate (sodium aluminum silicate) as well as other losses, soda ash must be added to the system and causticized with lime to form sodium hydroxide. By using two circuits external to the plant liquor circuit, the plant can recover most of the lime mud from causticization, rather than discarding it with the red mud as in usual Bayer plant practice.

Liquor from the primary causticizing stage feeds into the plant liquor as diluting liquor for the digester discharge; second-stage liquor dilutes spent-liquor feed to the evaporators.

Reconcentration of spent liquor from the precipitators involves evaporation of over 7,000 metric tons of water per day in quintuple-effect, climbing-film evaporators having 28-ft. tubes. Mixed feed (with half flowing forward to effects 4 and 5, and the other half flowing backward through effects 3, 2 and 1) together with carefully controlled flashing temperatures maximizes steam economy—CSC

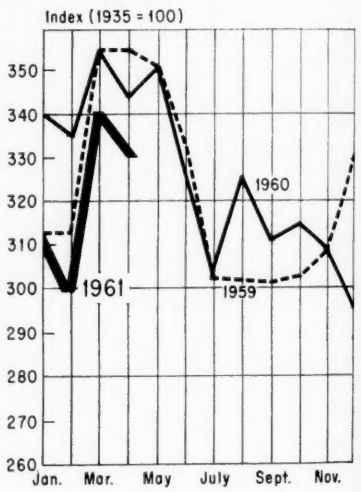
Petronaphthalene Capacity: Still Shooting Upward

Cities Service's announcement that it is going to build a 50-million-lb./yr. naphthalene plant at East Chicago, Ind., has many industry observers pondering what effect the buildup in petrochemical naphthalene capacity is going to have on the phthalic anhydride feedstock market.

Coming on the heels of Texaco's announcement of plans for a 100-million-lb./yr. naphthalene unit at Port Arthur, Tex., the Cities Service plant will bring announced petronaphthalene capacity to 500 million lb./yr. Other firms with units built or planned are: Ashland Oil, Tidewater-Collier, and Sun Oil.

Coke-oven naphthalene capacity is now estimated at 500 million lb./yr., while total consumption of naphthalene for phthalic anhydride in 1962 will probably be around 500 million lb. When all the petronaphthalene capacity comes on stream, therefore, a price struggle is a distinct possibility.

Also, since *o*-xylene producers are trying hard to squeeze into the phthalic market, a three-cornered battle could shape up.

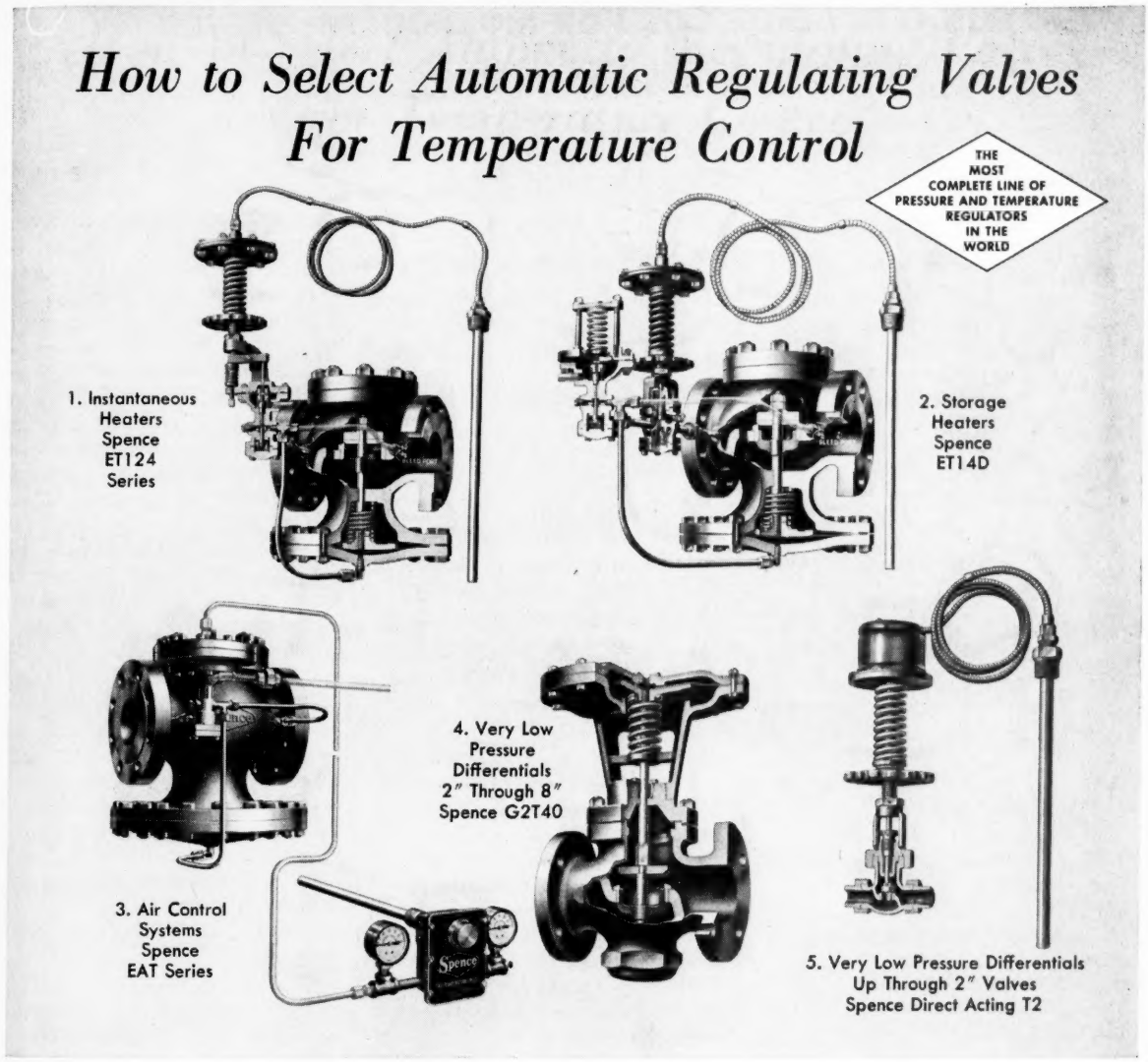


Chemical Consumption Index

	March (Final)	April (Final)
Coal products	6.9	7.2
Explosives	10.5	11.1
Fertilizer	88.8	82.1
Glass	32.6	29.2
Iron & steel	13.0	13.9
Leather	4.1	4.2
Paint & varnish	35.3	36.5
Petroleum refining	32.4	30.4
Plastics	32.1	34.2
Pulp & paper	44.3	44.1
Rayon	24.5	22.4
Rubber	6.6	6.4
Textiles	9.7	8.7
Total	340.8	330.4

VALVE TIPS:

How to Select Automatic Regulating Valves For Temperature Control


THE MOST COMPLETE LINE OF PRESSURE AND TEMPERATURE REGULATORS IN THE WORLD
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2. Storage Heaters Spence ET14D
3. Air Control Systems Spence EAT Series
4. Very Low Pressure Differentials 2″ Through 8″ Spence G2T40
5. Very Low Pressure Differentials Up Through 2″ Valves Spence Direct Acting T2

During the past year, our field representatives have reported many cases of improperly, and uneconomically, applied temperature regulators. To help you avoid some of these costly mistakes, here are a few tips on selecting the most effective and economical temperature regulating valves for your applications.

1. Instantaneous heaters require a special action for close temperature control and freedom from hunting. In the Spence ET124 series, steam pressure is modulated according to temperature (demand) and is automatically regulated at any pressure established by the demand.
2. Storage heaters, on the other hand, are more economically controlled by the Spence ET14D, which includes a simple temperature-actuated pilot that opens and closes the main valve to maintain a constant temperature.
3. Air control systems can now have a ±5°F control accuracy under wide and instantaneous load swings with the Spence EAT regulator. Engineers report savings of up to 50% in installed costs with this recently developed Spence cascade system when it has been used in place of conventional instrumentation.
4. For the combination of very low pressure differentials and air or water control, Spence recommends Type G2T40. This single seated valve provides fast, positive response in 2″ through 8″ valves. Double seat Type G22 is also available in 10″ through 12″.
5. When very low pressure differential is encountered with valves of 2″ or less, the Spence direct operated T2 is recommended. The sensitive vapor tension thermostat responds quickly to small changes in bulb temperature for continuous, accurate control.

In this brief description of industrial process and heating temperature control, we have given a few important tips in proper regulator selection. If you would like more detailed information on these control applications, write for the new Spence Temperature Control Bulletin IV 1014. SE-150

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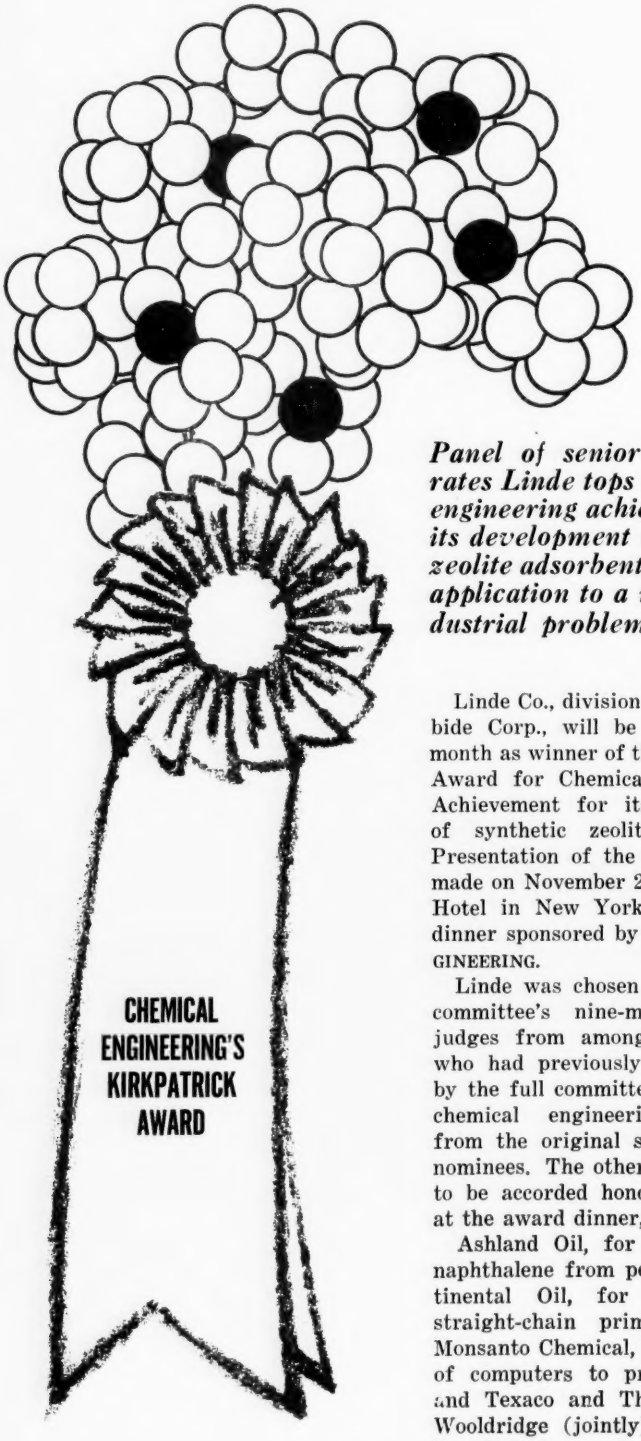
THE WINNER: LINDE CO., FOR MOLECULAR SIEVES



Panel of senior professors rates Linde tops in chemical engineering achievement for its development of synthetic zeolite adsorbents, plus their application to a range of industrial problems.

Linde Co., division of Union Carbide Corp., will be honored next month as winner of the Kirkpatrick Award for Chemical Engineering Achievement for its development of synthetic zeolite adsorbents. Presentation of the award will be made on November 28 at the Astor Hotel in New York, at a special dinner sponsored by CHEMICAL ENGINEERING.

Linde was chosen by the award committee's nine-man board of judges from among five finalists who had previously been selected by the full committee of 99 senior chemical engineering educators from the original slate of fifteen nominees. The other four finalists, to be accorded honorable mention at the award dinner, are:

Ashland Oil, for production of naphthalene from petroleum; Continental Oil, for synthesis of straight-chain primary alcohols; Monsanto Chemical, for application of computers to process control; and Texaco and Thompson Ramo Wooldridge (jointly) for first on-line digital computer control of an industrial process.

▶ **Basis for Award**—The Kirkpatrick Award for Chemical Engineering Achievement recognizes an outstanding technological accomplishment achieved through the group effort of chemical engineers. It is awarded to a company, to a department within a company, or to a group of companies—rather than to any individual. Criteria for judging the achievement are the difficulty of chemical engineering problems encountered and solved, novelty of the technology and evidence of commercial success.

Development of synthetic zeolites—or "molecular sieves," as Linde chooses to call these materials—encompassed a broad scope of chemical engineering activity. The contributions of chemical engineers in research, process development, plant design and production were matched by equally significant achievements of chemical engineers in the development of commercial applications for the products. In this latter area, Linde engineers have contributed to fundamental knowledge in the little-understood yet widely used unit operation of adsorption.

▶ **Not As a Stranger**—Linde was one of a group of companies that shared in the 1946 CHEMICAL ENGINEERING Achievement Award to the atomic bomb project. Other divisions of Union Carbide won or shared awards in 1933, 1943, 1946, 1953 and 1957.

Most recent winner was Texaco, honored in 1959 for development of the partial oxidation process for production of hydrogen and synthesis gas.

Although the Achievement Award has been given on fifteen previous occasions since its inception in 1933, this year will be the second time it bears the name of S. D. Kirkpatrick, retired editorial director of CHEMICAL ENGINEERING. As in years past, Mr. Kirkpatrick will preside at the November 28 dinner as toastmaster.

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E Sampling Multiplexer — Model 6012
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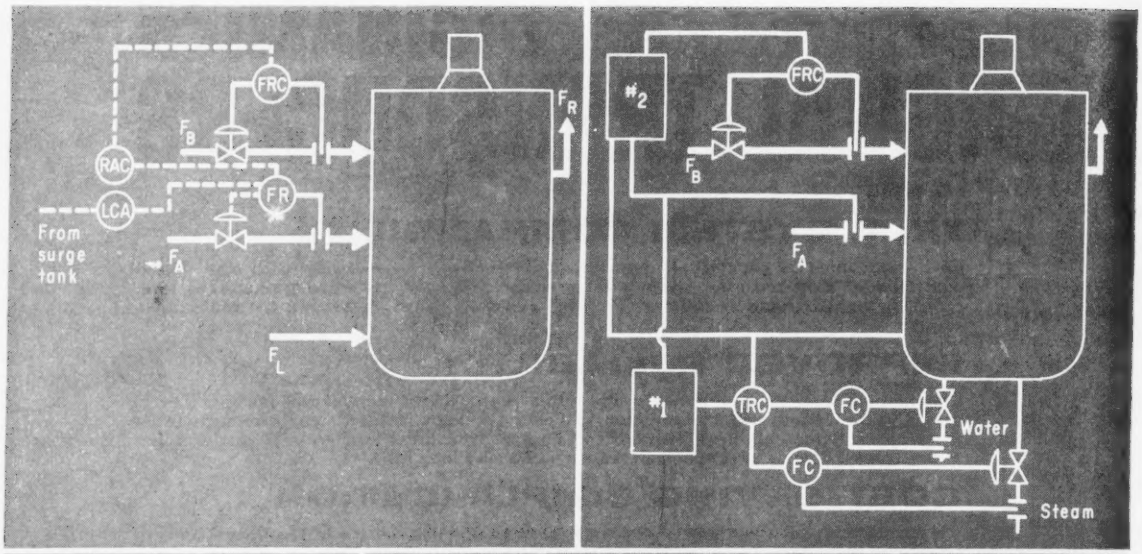

NEW ANALOG CONTROL COMPUTER DRAWS CPI CROWD

Applied to two problems well-known to process control men, special-purpose devices hold interest of many chemical engineers at big L.A. instrument meeting.

At the Instrument Society of America's 16th annual meeting in Los Angeles last month, process industry men had many questions for vendors of special-purpose analog computing devices.

At Garrett Corp.'s AiResearch booth, an island of interest to CPI men in the vast sea of hardware exhibits, a new pneumatic analog computer line was shown.

Like other lines of such equipment,* various components provide such functions as addition, subtraction, square root calculations and integration.

But unlike its better-established competitors, AiResearch is using a unique "signal cart" to transmit signals to and from the process. Fixed or riding on levers, these carts assume the main role in the computation. Control-signal air pressure acting on a diaphgram forces the cart against the lever, and cart position determines a torque action on the lever arm.

▶ **Computer Interest**—A combination of factors is responsible for the spurt of attention to small special-purpose analog computers.

Reaction after several years of exposure to large-scale digital-control computers is one. When the computer firms invaded the process industries in the late '50's, process men were novices in the techniques and approaches.

And the pressure was external. A plant engineer had little incentive to push the new concepts because they are hard to understand, hard to apply. In casual accounting, it's also difficult to determine success or failure of the payout.

Cost of the large-scale applications (for example, Monsanto's closed-loop computer control at its Luling, La., plant) is also a deterrent to wide-spread engineering acceptance. Investment may range

* Foxboro Co., Moore Products, Minneapolis-Honeywell Industrial Products Group, Taylor Instrument Cos., Republic Manufacturing Co.

ONE OF A SERIES OF CHATS ABOUT THE CONSERVATION AND CONTROL OF HEAT

SARCO TOPICS

WHY THE BIG STRAIN?

It's tough to keep gases and liquids "clean" as they run through a pipe. They drag impurities along, which can make even plain water a trouble maker, let alone more sophisticated fluids. That's because water, as a liquid or steam, is intimately involved with vital equipment like steam traps, temperature regulators, or tools. Meters, burners, nozzles, and pumps, too.

By this time you must realize we're going to talk strainers, don't you? A good, stout subject, of interest to all who feel production belongs up and costs belong down. Sarco makes strainers for water and condensate, steam, oil, air, gas and other piped fluids . . . dozens of different sizes and types and ratings of strainers to match every application need. Even our line of plain and simple strainers is built for super service. These are pipeline strainers, types AT, BT, and CT, which are designed for 250, 250 and 600 psi non shock, respectively, and 475°, 450° and 750°F. temperature ratings. Standard screens are heavy-gauge, perforated brass or stainless steel. Sarco specializes in screens that can withstand abnormal pressure differentials created by accumulated sediment.

Next, Sarco's flanged strainers, type D. These come in larger sizes, right up to 12", and are available in standard or extra heavy types.

And finally, *Sarco scraper strainers*, manual or motorized. These are the really eye-popping models, and if you can't use one yourself — well — you'll just have to get your kicks elsewhere.

Examples? Take Inland Steel Company at East Chicago, which gets water from Lake Michigan to cool its large air conditioner condensers. The water used to pass through traveling screens, but still contained fine sand. Clogging!

Heat under collars! Frequent cleaning required! Sometimes practically no air conditioning on hot days. (Isn't that always the way?)

The Inland Steel people installed Sarco Rotary Scraper Strainers, Type VRS, which incorporate a hand-operated helical scraper knife within the cylindrical strainer screen. A few turns of the crank at regular intervals, and the sand is scraped off the screen, blown clear, and discharged at pressure through a manual valve to waste. Dismantle the strainer? Shut down the unit? Not *this* strainer!

Now, as long as we've come this far, it's only a hop and a skip to the Firestone Tire and Rubber Co. in Akron, Ohio, who also use water in tremendous quantities. They circulate it through tire presses and a cooling tower, and there's no nonsense about it. It *has* to be clean or damage to equipment could be downright catastrophic. When the plant

modernized and enlarged, Firestone replaced their 4" Sarco hand-operated scraper strainer, type VRS, with a larger Sarco 8" model. And while they were about it, they got the motor-operated type, for continuous cleaning.

When we say that companies like these want the insurance of a Sarco strainer, it sounds like advertisingese, but sometimes there just isn't any other way to put it. Sarco strainers *are* insurance at low cost on the operation of your high cost equipment. So when we ask if you have lumps in your pumps, or worries over your slurries, we're *serious*. We've heard everything in the straining line, so why not write us for literature and answers to those special problems you have.

A T-44 IS THE BEST POLICY

Sorry, but we can't leave the subject of insurance without bringing to your attention one of the best little insurance policies any company requiring cooling control could invest in. It's the *self-powered* Sarco T-44 Automatic Cooling Control. No compressed air or electricity is needed, but its advantages are best described in terms of three different plants of just one Sarco customer — Revere Copper and Brass, Inc.

Revere-Baltimore, Md., has cut water use 40 to 50% with T-44's. But in addition to former water waste, Revere had even more problems: possible wet air from uncontrolled cooling of compressor aftercoolers, plus sweating compressor cylinders; variations in viscosity of hydraulic oil and bearing oil; gas generator water waste; unreliability of manual shut-off of water supply when machines were down.

If your ears perk up in sympathy at mention of any of these problems, the results of Revere's cooling control program should bring you to full attention. One large compressor that had gulped 2400 gallons per hour now takes only 420 gallon sips. In addition all the problems itemized above were solved. T-44's are now used on their air compressors, gas generators, and hydraulic oil systems. At Revere-Riverside, Cal., water savings of 50% were experienced, and at Revere-Rome, N. Y., substantial savings were made too.

But after all, wasting water is only one way of wasting money, so let's go on to another matter of interest: the evils of manual control. When cooling water is controlled by hand the temptation to leave the valve nearly wide open is almost overpowering, in order to play it safe if the load varies. Result: overcooling, of course. And varying the flow runs the risk of undercooling. In either case, lowered process efficiency. Answer: The automatic Sarco T-44, which can't be tempted, is meticulously honest, unsentimental, and plain inhumanly practical when it comes to cooling control. You really ought to write for literature. T-44 is your best policy.

SPARE PARTS INSURANCE

As long as we're near the end, and still on this subject of insurance, may we graciously leave you with this valuable tip? No matter how closely a steam trap approaches perfection, some gremlin may cause it to act up. It's conceivable. So, keep on hand a parts list and spares of key parts for your steam traps and other system components. Parts are small and worth their weight in gold when you need them. A Sarco field engineer will make up a suggested list for you, if you tell us what components make up your system.

Might as well even keep a disc or two on hand for your Sarco Thermo-Dynamic Steam Traps, Type TD-50, even though they're so trouble-free our salesmen keep complaining about the lack of replacement parts business. We'll be glad to tell you about this unique steam trap in case you still don't know how miraculously simple and effective it is.

Pardon our monopolizing the conversation in this series of paid communiques, but we're trying our best to interest you in certain subjects that concern us both — to the point where you'll communicate.

5903

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from $\frac{1}{2}$-$\frac{1}{2}$ million. Decisions on analysis, design and purchase, therefore, are diffused throughout the process organization and the computer vendor firm.

▶ **Up to Individual**—These same factors argue for an eventual wide acceptance of the small analog devices.

Though the magnitude of the control optimization function they perform can't be compared to that of the large digital devices, there are still many economies that can be affected by using these special-purpose computers. The beauty of their use is that a perceptive engineer can handle the whole project, from concept to operation, and show visible profit to his boss.

In the nearly 30 years that the special-purpose computers have been used, Btu. rate, gas-flow computation and determination of efficiencies have been common applications.

(Only rarely do these projects fail to pan out. But if they do, it's no great loss: the inexpensive equipment can be pulled off, reapplied to another place in the wide realm of a plant's nonoptimal control points.)

▶ **Displaying the New**—That AiResearch has seen these selling points is proved by its push into the new—for it—process industry field.

And the firm, whose primary interests have been heretofore in aircraft systems, chose an interesting and informative way to call attention to its computing device.

By applying it to two problems that have received wide-spread publicity in the process industries, industry men got a chance to compare it with previous solutions.

The first control problem is that of holding internal reflux constant in a distillation column. As pointed out by Phillips Petroleum Co.'s Tom Wherry (*Chem. Eng.*, Dec. 12, 1960, p. 156), this device fills a role that probably can't be economically handled by a digital computer.

Other instrument firms have put such a unit on the market—e.g., Taylor Instrument Cos. and Minneapolis-Honeywell — based on the original Phillips Petroleum work. There's even an electronic version, sold by Electronic Associates, Inc. And many of the units are in use: Phillips alone may have a dozen and a half.

The second control problem is one met by many process men—the optimal control of a continuous-flow stirred-tank reactor (CFSTR). This particular CFSTR, however, is a hypothetical one, although a fairly well-known one.

▶ **Trying Better Approaches** — Readers of CHEMICAL ENGINEERING will recognize the CFSTR problem as one that appeared in the series of articles on systems engineering by Ted Williams of Monsanto Chemical Co. Originally posed within an AIEE committee, the hypothetical CFSTR is shown on p. 48 with its original instrumentation.

Details of this reactor are covered in the Williams series (*Chem. Eng.*, May 30, 1960, p. 98; June 27, 1960, p. 117), but there is one important point. Feed A to the reactor comes from a batch process, feed B is essentially unlimited. The batch process cycle is random and leads to a tough feed fluctuation in the CFSTR.

A conventional solution to the problem, shown by broken instrument lines in the diagram, adds a surge tank, and ratios the flow of reactant B to that of reactant A.

Besides suggesting this answer, however, Williams also proposed a solution in which changes in reactor temperature level could correct the residence-time affects of the fluctuating feed (*Chem. Eng.*, July 25, 1960, p. 122).

Other solutions were presented at the first Joint Automatic Control Conference in Cambridge, Mass., in September 1960. All of these involved application of large-scale digital computers to real-time control. One such solution, by Gould and Kipiniak of M.I.T., was adapted by AiResearch in its analog approach to the CFSTR control problem.

▶ **How Analog Does It**—Diagram at the right on p. 48 shows how engineers at AiResearch solved the control problem with their new "signal-cart" devices. Details of the two main computer control sections are shown below the reactor diagrams.

Computer mechanization of section 1 adapted the equation

$$2(P_o/2) = 0.0279(P_1/2) + 8.325$$

where P_o is the setpoint signal for temperature recorder-controller, and P_1 is the flow rate of reactant A. (P, refers to air-supply pressure.)

Section 2 of the computer is more complicated. Still, the expression that AiResearch engineers wrote is a linear algebraic one. In the hardware diagram of this section, P_2 is setpoint signal for reactant B flow rate, P_3 is reactor temperature.

▶ **Dollars and Sense**—An advantage of pneumatic elements (either those of AiResearch or of the several other manufacturers) is their easy adaptability to standard process control systems.

Accepting 3-15 psi. pneumatic inputs, the components require no transducing of signals to or from electric form. And besides arithmetic functions, the units can also handle ratios, differentiations and function generation.

Cost of the analog devices is, claims AiResearch, comparable with the competing devices of other firms in the field. That would put it, roughly, at about $150 per mathematical function if you put the computer together yourself, up to $300 per function if you buy the computer. Without the control instrumentation, the CFSTR computer would cost about $2,500.

Accuracy of the devices—those of other manufacturers as well as AiResearch—is better than the rest of the control system, may run from $\frac{1}{2}$-1%. With careful calibration, the over-all control system may attain an accuracy of $\frac{1}{2}$-3%.

There are many big opportunities in most process plants to tackle problems that can be solved with the special-purpose computers. An article by George Plant of Wyandotte Chemicals Co. (*Chem. Eng.*, June 12, p. 205) emphasized it this way: "What is needed is an economic bridge to that more-formidable application, digital-computer control, which will improve control at less cost. That bridge may be . . . analog-computing elements."—WCS

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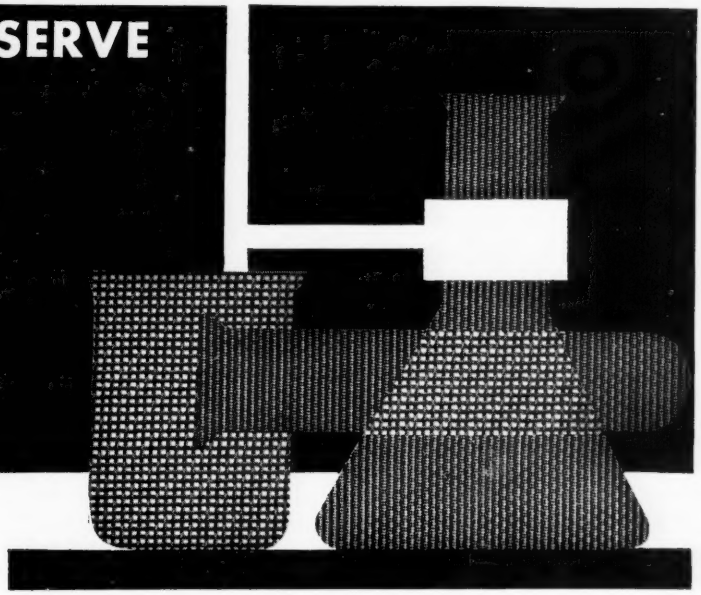

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LOWER PHENOL PRICES STIR UP THE PLYWOOD ADHESIVES MARKET

The trend towards captive phenolic resin production may change plywood technology and provide a big new outlet for phenol.

The price cut in phenol to 16¼¢/lb. (*Chem. Eng.*, Sept. 18, p. 61) has set in motion a chain of events that could have great effect on the plywood and resin industries in the Northwest. Three changes are likely: (1) more plywood firms will start captive production of phenolic adhesives; (2) adhesive-resin makers, seeing markets shrinking, will diversify; (3) phenolics will capture a greater share of the plywood business.

Two of the big plywood manufacturers, Georgia-Pacific Corp. and Simpson Timber Co., already make all of their own resins. Simpson's capacity is unknown, but Georgia-Pacific puts the phenolics capacity of its Coos Bay, Ore., resin plant at 15 million lb./yr.

With phenol's lower cost making phenolic resins more competitive with casein and urea-formaldehyde resins, other plywood producers are expected to get into captive production. Weyerhaeuser Co. and U. S. Plywood Corp., for example, are seriously studying such moves.

Besides being the best-performing glue, phenolics are also easiest to make captively. Thus, once a company gets into captive production, the lower cost would encourage substitution of phenolics where other resins are now used. This could boost phenolics' share of the plywood market from the current 35-40% up to 75%.

Resin manufacturers obviously are not happy with the swing towards captive production. In a countermove, Monsanto recently whacked phenolic resin prices by 20%, bringing them down to 8¢/lb. With phenol at the old price of 17¢/lb., the lower resin price no longer made captive production attractive.

But by lowering the price of phenol—thus making captive production again profitable—phenol producers were in effect indicating that they expect the plywood makers to be big future customers.

In answer to the advocates of captive production, resin makers point out that the technical service they provide has enabled the glueline cost to drop from $6/1,000 sq. ft. down to $2.50 in recent years—the only plywood manufacturing cost to come down. But if captive resin production becomes an industry-wide reality, these spokesmen declare, then it may spell the end of developments in adhesives, since most plywood companies won't want to spend the amount of money for research that the resin companies have.

To protect themselves from possible loss of markets, some resin makers are turning to diversification. One of the pace-setters in this swing is American-Marietta Co., which has gone into making epoxy resins for the electronics industry, plastic buttons for traffic markers, and a wet-web system for the plywood industry. There are also reports that some resin producers might move into fabrication of specialty plywood products. With the present depressed state of the plywood business, however, this doesn't seem to be an immediate prospect.

Lower phenolic resin costs might also hasten industry standardization on a single grade of phenolic-bonded plywood. Several obstacles still block this much-discussed goal, however. Main one is the need of hot presses to process phenolics (while protein glues are handled in cold presses). This means that many plants would have to buy hot-press equipment if standardization became a reality. But much research is being done on activating phenolics in a cold press and, if successful, it would provide a great impetus towards standardization.

If one grade becomes accepted, a phenol market for 80-100 million lb./yr. would exist in the Northwest—outstripping present capacity in the area. Dow at Kalama, Wash., is building 36-million-lb./yr. of capacity; Monsanto at Avon, Calif., has 36 million lb.; Oronite in Richmond, Calif., 50 million lb. Allied is considering a phenol plant in the Northwest also, possibly including a market tie-up with Georgia-Pacific that might account for 10 million lb./yr. But with present overcapacity in the Northwest, a new phenol producer would have to believe that phenolic resins are in for substantial growth.

Liquid CO_2 Seeks Jobs In Mobile Refrigeration

Consumption of liquid carbon dioxide, which has grown almost 60% since 1954, may get another big boost via refrigeration of frozen and perishable foods in transit.

A system that uses liquid carbon dioxide as a refrigerant in truck and truck-trailer bodies has been developed by the Cardox Div. of Chemetron Corp. It is said to provide increased reliability—with a considerably lower temperature range than is now available in mechanical units. In operation, carbon dioxide is carried in tanks suspended under the truck body and is piped directly to the truck's interior.

Illustrating the market growth that CO_2 has enjoyed, latest Dept. of Commerce figures show production of liquid and gaseous carbon dioxide rose to 471,368 tons in 1960, up almost 60% from 1954. The widespread shift in industrial production toward greater use of automatic processes has boosted consumption of liquid, according to Cardox, because the liquid is more easily controlled and metered than the solid.

Liquid nitrogen is already being used in much the same way to cool rail cars, truck trailers and delivery trucks. Linde's Polarstream system, introduced commercially earlier this year (*Chem. Eng.*, Sept. 4, p. 58), employs a tank that releases

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Figs. 704-T and 704-B—TYPE 316 STAINLESS STEEL—SIZES ¼" to 2"
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liquid coolant on a signal from a thermistor-activated valve. Linde's valve, however, is powered by an electric battery whereas the Cardox valve is moved by gas pressure. Freedom from a battery, Cardox believes, facilitates mobility of its system during piggy-back movements.

Cost of both systems—liquid carbon dioxide and liquid nitrogen—depends on volume of liquid consumed, and both claim to be competitive with costs of mechanical systems. According to Linde, however, Polarstream provides more refrigeration per pound of liquid: liquid nitrogen discharged into a 70 F. chamber can absorb 165 Btu./lb., compared with 90 Btu./lb. for carbon dioxide. Price of both liquid nitrogen and liquid carbon dioxide averages about 3¢/lb., when sold in quantity.

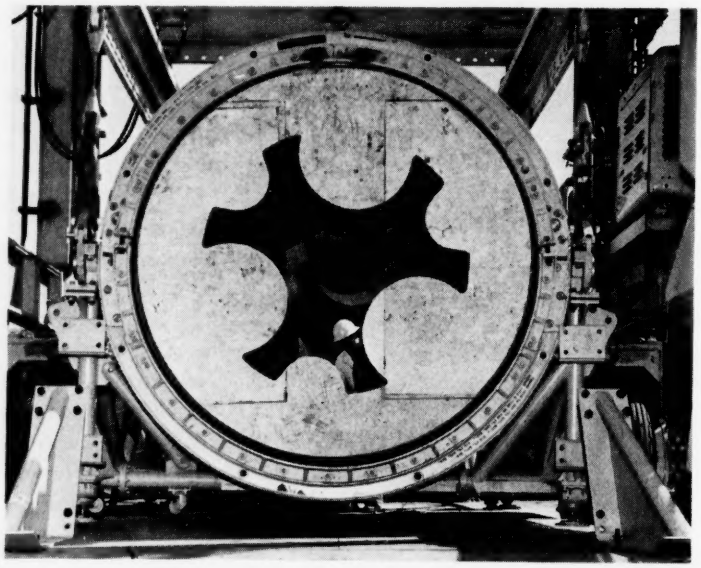
Soviets List Achievements In Nuclear Energy Field

In a recent issue of *Izvestia*, Vasili Yemelyanov, chairman of the U.S.S.R.'s State Committee for Atomic Energy, sums up some of the Soviets' latest nuclear achievements. Biggest news is a reference to a 50-billion-volt proton accelerator now under construction in the Soviet Union. He gives no details, but this giant unit is said to be "one of several" due in operation "in the next few years."

In his round-up article on the progress of the nation's nuclear program, Yemelyanov also:

- Hints at new sources of atomic power through annihilation of particles, e.g., by combining a proton with an antiproton, theoretically releasing energy some 1,000 times greater than that given off by conventional thermonuclear reactions.
- Places high hopes on fast neutron reactors, noting that "one of our main tasks is the creation of a reactor in which thermal energy from nuclear processes is converted directly into electrical energy."
- Points at three big nuclear power plants now being built: a 100,000-kw. unit at Beloyarsk in the Urals, and two 210,000-kw. stations at Voronezh.
- Notes that plasma research such as will be carried out in the new proton accelerator requires near-total vacuum and strong magnetic fields, toward which "great progress" has been made (several types of "large" experimental evacuators and magnets have been created or are under active development).
- Mentions that Soviet technicians are helping to build a 150,000-kw. atomic power station in Czechoslovakia, and a 70,000-kw. reactor in East Germany.

Solid-fuel segments grow fatter as space race heats up



A technician at Aerojet-General Corp's rocket engine plant in Sacramento, Calif., stands between the two center segments of the largest solid-fueled rocket motor fired to date. The two 8.3-ft.-dia. segments, when mated with fore and aft sections, developed a thrust of 500,000 lb. in a static test. Conducted for the Air Force, the firing was the latest in a test series designed to develop a multimillion-lb.-thrust solid booster for use in manned moon shots. Aerojet hopes to fire a 1-million-lb.-thrust segmented rocket by the end of 1962.

Biocide May Eliminate Bacteria in Hydrocarbons

Microbiological life can lurk for months in anhydrous hydrocarbons, but a bacterial population explosion occurs as soon as moisture appears. This observation was reported by R. J. DeGray of The Standard Oil Co. (Ohio) during the recent annual meeting of the American Institute of Biological Sciences at Purdue University.

DeGray's discovery shatters the earlier belief that bacteria would not survive in hydrocarbons without the presence of free water. His finding is of more than academic interest: microorganism growth resulting from moisture condensation from the air can, for example, corrode jet fuel tanks and clog fuel lines. A boron-containing biocide, currently in the research stage, may be an answer to this problem.

When the problem is temperature, specify ANACONDA stainless steel hose

Anaconda's flexible stainless steel hose is being specified more and more for rugged assignments, and is living up to its reputation for dependability. It is being used to convey steam, hot water, fuels, cryogenic fluids, air, gas, liquids, corrosives, chemicals . . . in installations where temperatures may vary from −300°F to 1000°F.

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Whenever you have a connector problem, consult Anaconda Metal Hose. Hose in a wide variety of metals and materials to meet every requirement. For more information write . . . Anaconda Metal Hose, P.O. Box 791, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 61-938

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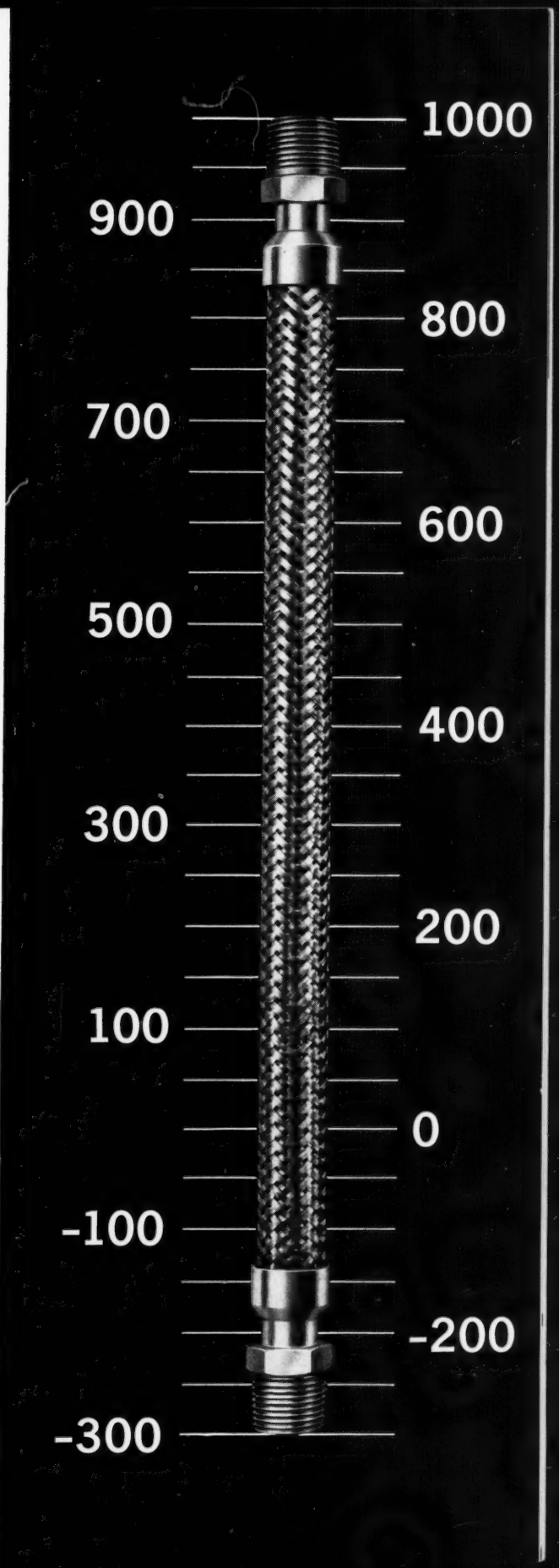
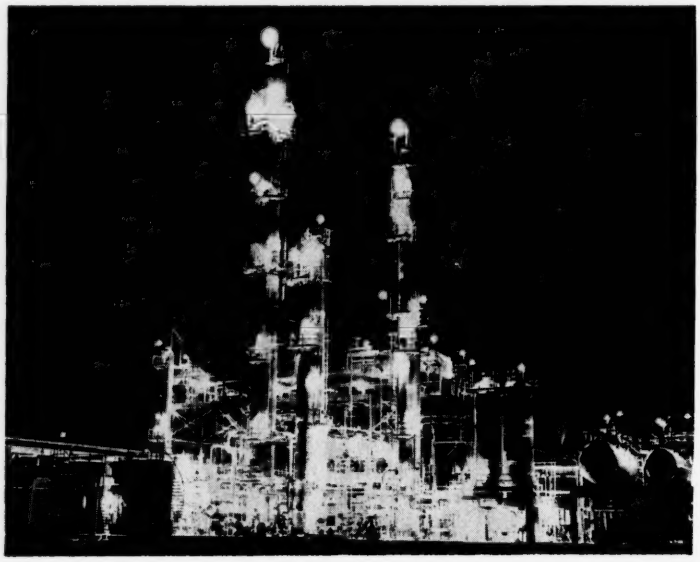


Benzene in round-the-clock production at Sweeny, Tex.



Glowing under the lights of nighttime operation, Phillips Petroleum Co.'s high-purity benzene unit (above) was placed on stream at the firm's Sweeny, Tex., refinery, four months after Procon Inc. began construction. Licensed from Universal Oil Products Co., the UOP Udex plant turns out 1,500 bbl./day of benzene.

Plants

Texaco Inc. plans to build a 100-million-lb./yr. naphthalene plant at its refinery in Port Arthur, Tex. The new facilities are expected to go on stream by early 1963, to derive naphthalene from petroleum feedstocks. The move is another expansion of Texaco's activities in petrochemicals, which already include plans for benzene (*Chem. Eng.*, Jan. 9, p. 56) and cumene (*Chem. Eng.*, Oct. 3, 1960, p. 52).

Standard Packaging Corp.'s board of directors has approved a plan to build a multimillion-dollar plant to produce metalized paper and paperboard. To be built in two phases, the first unit will begin commercial production in Aug. 1962; the second is expected to be constructed a year or two later. As much as a $64-million market potential may exist for this type of product, according to company-sponsored studies. Cigarette and food wrappings and folding cartons are some of the applications expected to boost product sales.

The Houston Corp. is "reviewing proposals" for the engineering and construction of a liquid-hydrocarbon extraction plant near Brooker, Fla. Tentatively scheduled to begin operating next July, installation would cost $6.25 million.

National Bagasse Products Corp. has announced the start of construction of a $2-million plant in Vacherie, La., for the manufacture of hardwood board from bagasse (the pulp fiber from sugar cane). Scheduled to begin operations in early 1962, the plant will turn the cellulosic raw material into 20 × 5-ft. hardwood sheets that range in thickness from ¼ to 2 in. Georgia-Pacific Corp. will sell and distribute the plant's products, which will compete with structural materials such as wood, plywood and wood-particle board.

Continental Carbon Co.'s $4-million carbon black plant and laboratories at Bakersfield, Calif., have begun operation. Plant capacity is 50 million lb./yr. of oil furnace black, which is used chiefly in rubber compounding. Witco Chemical Co., worldwide distributor of Continental Carbon's products, will market the output.

Linde Co., a division of Union Carbide Corp., has placed a 310-ton/day oxygen unit on stream at Bethlehem Steel Co.'s Lackawanna, N. Y., facilities, replacing a 110-ton/day plant built in 1957. Constructed and to be operated by Linde, installation will chiefly supply Bethlehem's open-hearth furnaces; some output, however, is slated for scarfing operations at the steelmaker's new slabbing mill.

Tenneco Oil Co. is doubling capacity at its natural gas processing plant in Matagorda County, Tex. New rate will be 90 million cu. ft./day, with production of de-ethanized product increased proportionately.

Monsanto Chemical Co.'s Inorganic Chemicals Div. will begin constructing a plant early next year at Augusta, Ga., to produce phosphoric acid and sodium tripolyphosphate. (Latter is a building block for household and industrial detergents.) Neither cost nor capacity has been announced; unit is due on stream early in 1963. As the market warrants, undisclosed manufacturing units for additional products will be built.

Hawkeye Chemical Co. has been created jointly by Swift & Co. and Skelly Oil Co. to construct a $10-million nitrogen products plant near Clinton, Iowa. Rated capacity

Turn to p. 138 for more CPI News Briefs

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As a result leading engineering-construction firms now use Fluoroflex rigid piping systems and flexible components in new plant construction to stop corrosion or contamination and to reduce erection costs.

■ **Fluoroflex preflanged piping** eliminates cutting chamfering, cleaning, welding, scale, flux, weld spatter and annealing—minimizes the need for gaskets, hangers, supports, and anchors as required for non-metallic piping.

Many small processing columns can be assembled from sections of Fluoroflex-lined pipe for rectifying, absorption, and scrubbing operations. Packed Fluoroflex-lined columns complete with Fluoroflex distributor and support plates and Raschig rings can be fabricated in sizes up to 10 inch diameter.

■ Resistoflex also manufactures a complete line of bellows and expansion joints, transfer hose, dip pipes, spargers, and thermowells.

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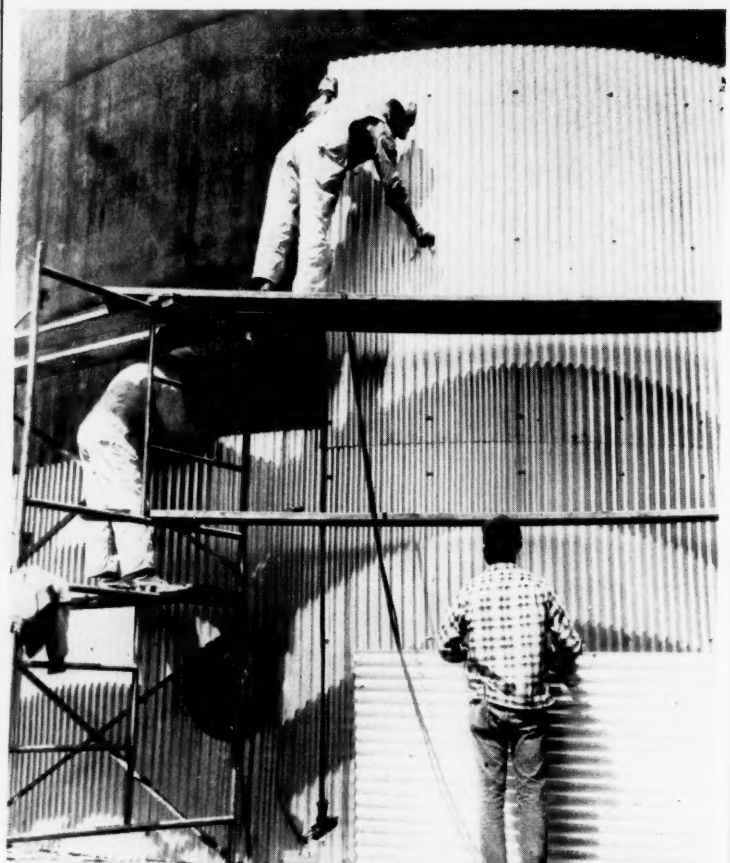

The panels above are made of an efficient insulating material with a diamond-rib sheet-aluminum facing. Called Speed-Insul Panels, they cut the time and labor needed for insulating outdoor equipment. They can be cut and drilled, as necessary, in the field with a standard electric sabre saw and hand drill, and quickly fastened with threaded studs to the surface to be insulated.

The insulation, Spintex, is felted from long, tough siliceous fibers by a spinning process that adds countless heat-stopping dead-air spaces to the material, thus lowering its thermal conductivity to about 0.23 Btu./(hr.)(sq.ft.)(F./in.). Spintex doesn't burn, and will neither rot nor mildew. —**Johns-Manville Corp., New York.** **58A**

Benzoyl peroxide

Polymerization catalyst in improved paste form is fire resistant and quick to disperse.

U.S. Peroxygen Corp. is offering a new formulation of benzoyl peroxide paste, BZQ-50, that performs better than the standard (BZO-50) paste based on tricresyl phosphate. These benzoyl peroxide pastes are primarily employed as polymerization catalysts for monomeric vinyl, styrene and polyester resins, and copolymers of these resins wherever an ester-type plasticizer is favorable.

The new formulation is fire resistant (ignition point 240 F.), has an even consistency, and quickens the curing time in each application because it provides a uniform benzoyl peroxide concentration. Its fine particles dissolve rapidly in polyesters and other polymers without causing color degradations upon aging or in storage.

Benzoyl peroxide is perhaps better known as a catalyst for the side-chain bromination and chlorination of alkyl-substituted benzene compounds and for graft polymerization. In its nonseparating paste form, this peroxide is now finding other applications among industrial molders, autobody putty manufacturers and boat builders.

BZQ-50 can be used either alone or in conjunction with other pregelling organic peroxides such as methyl ethyl ketone peroxide, cyclohexanone peroxides and cumene hydroperoxide. — **U.S. Peroxygen Corp., Richmond, Calif.** **58B**

Alkaline cleaner

Solvent can remove rust and heavy scales within minutes.

In one operation, an alkaline solvent now removes rust, paint, oil, grease and shop soil from metals. Known as Endox L-76, it is a nonflammable liquid combination of chelating agents and strong alkalis.

Work to be cleaned, derusted, or stripped of paint, is simply immersed in a hot (170 to 220 F.) bath of full-strength Endox until the metal surface is clean. Usually, 1-5 minutes is sufficient for cleaning; 5-15 minutes permits removal of heavy rust.

This solvent is effective for cleaning steel prior to phosphating, blackening or painting. It also cleans copper and brass, removing tarnish as well as soil, and loosens tough scales sufficiently to considerably shorten pickling.

Removal of many baked syn-

Growing use for urethane coatings: making economical patent leather coatings. Shell's versatile Pent-Oxone high boiling solvent works well in urethane and most other coatings, eliminates need for premium-priced specialty solvents.

URETHANE FORMULATORS:

Shell's multi-purpose Pent-Oxone* solvent gives you the advantages of a specialty high boiler for urethane coatings—yet lets you reduce solvent inventory

Shell's Pent-Oxone solvent is excellent for two-package urethane coating systems. You can also use it to good effect in almost every other type of surface coating you make.

Result: reduced inventories for the specialty coating formulator who doesn't want to stock premium-priced specialty solvents.

SHELL CHEMICAL's Pent-Oxone solvent combines both ketone and ether functional groups in a unique new keto-ether molecule.

As you might expect, this remarkable structure makes Pent-Oxone an outstanding and versatile solvent.

Good urethane solvent

Pent-Oxone solvent is a true high boiler, with an even evaporation rate midway between the evaporation rates of cyclohexanone and EGMEE acetate.

In urethane coating systems, Pent-Oxone solvent combines strong and effective solvency with low isocyanate reactivity. Pent-Oxone has no labile hydrogen and never needs to be upgraded for purity.

Viscosities of typical urethane coatings, using 40 parts solids in 100 parts of 50/50 Pent-Oxone/xylene, range between 11.5 and 53.0 cps. after one-day storage.

Isocyanate percentages remaining after eight-week storage of Pent-Oxone solvent and toluene di-isocyanate (25 per cent in toluene) are on the order of 96.2 per cent.

Lets you reduce inventory

Pent-Oxone solvent is extremely versatile. By using it in other coating formulations, you can reduce high boiler inventory.

In acrylic lacquers, Shell's Pent-Oxone solvent will give you outstanding gloss and excellent flow. Its solvency is in all respects equal to that of EGMEE acetate.

In vinyl lacquers, Pent-Oxone can lower your high boiler costs and give you a better-smelling product.

In nitrocellulose lacquers, Pent-Oxone solvent provides low viscosity, good flow-out and excellent blush resistance. Its dilution ratio is comparable to that of low boilers.

You will also find Pent-Oxone solvent an excellent high boiler for cellulose acetate butyrate lacquers, for alkyd and epoxy enamels and for thermosetting acrylic coatings.

New technical bulletins

New technical bulletins are either available or being prepared on all these applications, as well as on the general properties of Pent-Oxone solvent and its near relation, Pent-Oxol* glycol ether solvent.

To get copies, plus samples, contact any of Shell's 9 Industrial Chemical offices, or write directly to Shell Chemical Co., 110 W. 51st St., New York 20, New York.

*Trademark, Shell Chemical Co.

Shell Chemical Company

SHELL

Industrial Chemicals Division

thetic enamels from steel, copper, brass or magnesium is also reported to occur quickly and economically. — **Enthone Inc., New Haven, Conn.** 58C

Water repellent

Nonionic emulsion can waterproof textiles and improve their crease resistance.

Unlike silicone or pyridine quaternary and fatty amide types, a new water repellent will make textiles resistant to both dry-cleaning and laundering. Called Argus DWR, this product is described as a nonionic emulsion polymer (probably of a waxy nature), white in color and with a 43-45% solid content.

It has been developed specifically for fibrous materials (cotton, wool, rayon, nylon, Dacron, Orlon, and blends) on which it can be cured by several catalysts, including the preferred zirconium oxychloride catalyst. Argus DWR equals silicone repellents for resistance to dry-cleaning, and pyridine quaternary and stearamide type repellents for wash-fastness. Actually, it is superior because it does not leave objectionable odors on fabrics and thus eliminates the usual washing after the fabrics are treated.

According to the manufacturer, the new repellent is compatible with such wash-and-wear resin finishes are urea formaldehyde, melamine, ethylene urea, triazone, triazine, acetal and epoxy resin finishes. With these, it enhances wash-and-wear properties and improves crease and scuff resistance, and tear strength. Argus DWR is being marketed as a finish for nonwoven fabrics and paper.—**Argus Chemical Corp., New York.** 60A

Epoxies

New resins will go into missiles' motor casings and nose cones.

Two new epoxy resins, Bakelite ERL-2256 and 2258, can be used for filament-winding systems of high tensile elongation and good handling properties. Both are reported as difunctional compounds with a long pot life and, properly cured, will exhibit excellent mechanical properties. They can be cured with anhydrides and aromatic amines at room temperature but are not recommended for use with methyl nadic anhydride.

Both resins can also go into laminating applications. ERL-2256, with a viscosity range of 500-900 cps. at room temperature, has been especially recommended for wet lay-up and bag molding. This resin has boosted flexural, tensile and edgewise compressive strengths of glass-reinforced structures to values several thousands psi. higher than those required by military specifications Mil-R-9300A, Type I.

Hardened with a modified eutectic blend of aromatic amines, ERL-2258 has excellent filament-winding handling properties because it won't undergo viscosity increases for periods as long as 8 hr., and acquires a 7% tensile elongation and a heat distortion point of 160 C.—**Union Carbide Plastics Co., New York.** 60B

Surfactants

Several detergents can be made from alpha-sulfonated fatty acids.

Alpha-sulfopalmitic acid and alpha-sulfostearic acid, structurally $CH_3(CH_2)_{13}CH(SO_3H)COOH$ and $CH_3(CH_2)_{15}CH(SO_3H)COOH$, are two new anionic surfactants that can be formulated into detergents, greases or flotation agents.

Known as Armosul 16 and Armosul 18, respectively, both acids are off-white, slightly hygroscopic powders that are soluble in water and polar organic solvents, but insoluble in aliphatic hydrocarbon solvents.

▶ **True Sulfonates**—As revealed by the general structure, they are true sulfonates and not sulfated products. As such, they are stable to hydrolysis because of their carbon-sulfur bond; whereas sulfates, with a carbon-oxygen-sulfur linkage, are unstable.

In addition to their stability to hydrolysis, Armosul acids also possess hydrophobic properties imparted to them by the long alkyl group preceding the sulfonic and carboxylic acid groups. With these acidic groups of different strengths, one can prepare mono-, di- and mixed salts. Neutralization is stepwise; the stronger sulfonic acid group is completely neutralized before salt formation occurs at the relatively weaker carboxylic group.

▶ **Applications**—As reported by U.S. patent 2,915,473, improved detergent compositions of potentially lower cost and with good solubility properties can be obtained by combining alkali metal, ammonium, or substituted ammonium salts, of sulfated aliphatic alcohols with similar salts of alpha-sulfonated fatty acids. In addition, improved detergency can be obtained by replacing some of the alkyl aryl sulfonates, which are relatively ineffective detergents,

Newsworthy Chemicals

Page number is also reader service code number

Siliceous fibers and aluminum team up in new insulation.....58A
Benzoyl peroxide in paste form disperses quickly.....58B
Alkaline cleaner removes rust and scale within minutes.....58C
Nonionic emulsion waterproofs textiles.....60A
New epoxy resins can go into filament winding.....60B
Sulfonated fatty acids can make several new detergents.....60C
Polypropylene finds new applications as an adhesive.....62A
Emulsifying agent is also used in leather processing.....62B
Phenolic silicone adhesive withstands up to 1,000 F.....62C
Reinforced fluorocarbon has 500 times the strength of Teflon.....62D

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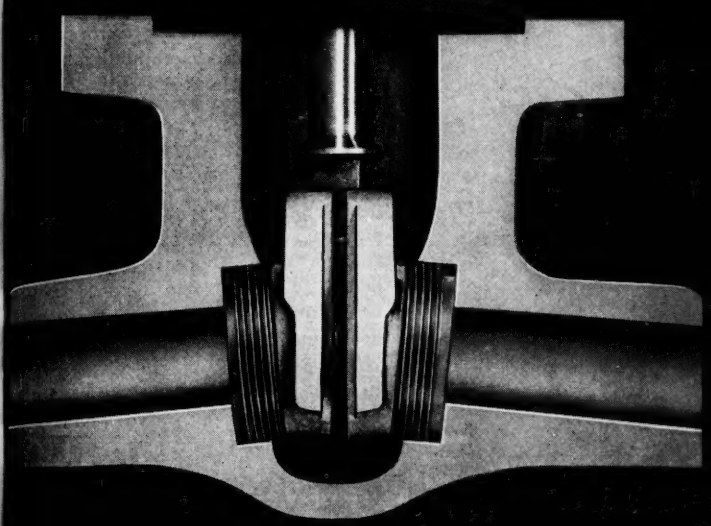
POSITIVE-LY NEW!!

CHAPMAN BI-VALVES

Chapman's new Bi-Valves are designed around a different swivel disc principle which guarantees automatic self-seating and positive shutoff on both upstream and downstream faces. Bi-Valves offer economy and performance unobtainable up to now.



GLOBE VALVE PERFORMANCE AT GATE VALVE PRICES

EXCLUSIVE BI-VALVE FEATURES:

1. Automatic positive seating, absolute shutoff
2. Interchangeable with solid wedges
3. Reversible for wear compensation
4. Disks changed without removing valve from line
5. Standby valves eliminated
6. Galling and seizing on seating surfaces minimized
7. Reduced spindle thrust
8. Replaces double valving under certain conditions
9. Unaffected by pipeline strains, temperature swings, welding heat or other loads induced by the pipeline
10. Will not stick when closed hot and opened cold
11. Maintenance time and cost drastically reduced
12. Available in sizes from 2" up, all pressure classes in steel at no increase in price

CHAPMAN BI-VALVES WILL REVOLUTIONIZE THE THINKING ON VALVES.
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with a mixture of salts of Armosul acids and sulfated alcohols.

By partial neutralization with an amine or mixture of amines, the monosodium or monoammonium salts of the new acids can also be used as the main ingredients for detergent bars. A salt of Armosul 18 may be used to advantage in the production of high-dropping-point greases; U.S. patent 2,951,809 reports the use of dilithium alpha-sulfostearate for the preparation of greases with dropping points above 500 F. Some salts have also been effective as flotation reagents for the removal of mineral impurities from silica sand.—**Armour Industrial Chemical Co., Chicago.** 60C

Taffylike polypropylene adhesive

This is a strange kind of polypropylene. It sticks, stretches, is easily melted, is compatible with a number of other resins and with most waxes, and is soluble in most aromatic and aliphatic solvents. Defined as amorphous polypropylene of low molecular weight, this tacky elastomer will go into hot-melt adhesives for laminating and sealing, and in caulking and potting compositions.

It is currently available in two grades: one is a tacky elastomer; the other, similar to a moderately heavy grease. Its unusual physical properties and compatibility have produced novel blends with a number of waxes. In many applications so far, the elastomeric type has imparted flexibility to olefin waxes and resins.—**Eastman Chemical Products Inc., New York.** 62A

Briefs

Emulsifying agent, Tanoyl OGX, can be employed as a topping agent and as a driving or penetrating agent in leather processing. A blend of alkyl-aryl sulfonates and natural emulsifiers, Tanoyl OGX is a smooth, light-yellow paste that flows at room temperature. As a topping agent, it cleans the surface of excess grease without creating looseness or discoloration when applied in quantities of 1-2%. It is also effective on lightweight skins to drive in clays, fillers and white pigments. — **Nopco Chemical Co., Newark, N.J.** 62B

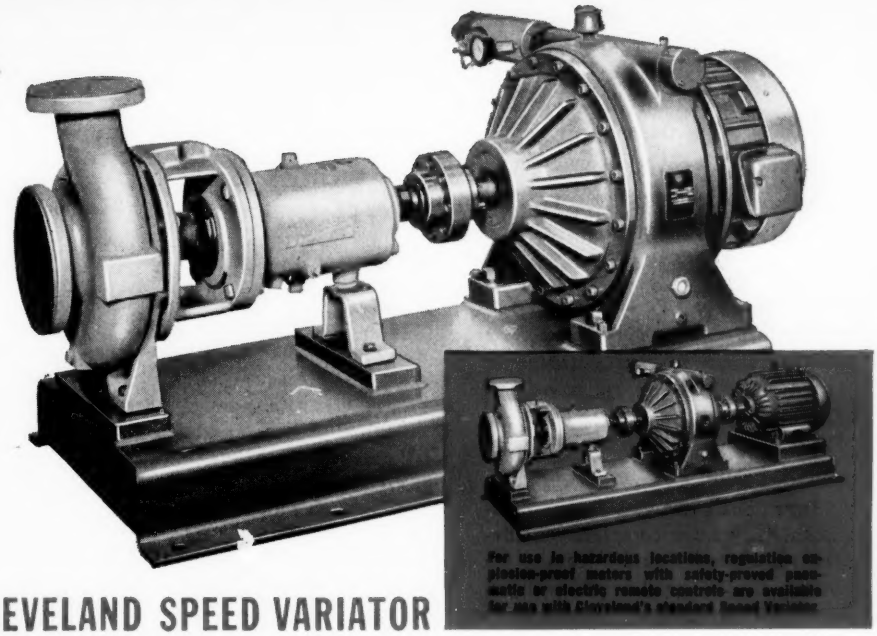
Phenolic silicone adhesive, Raiseal 350, will protect electrical components at temperatures as high as 1,000 F. Product is under consideration for bonding copper to glass-fiber epoxy laminates, and for other similar laminates that require high temperature and electrical resistance. Raiseal-pretreated asbestos forms are described as effective insulators for potted electrical components.—**Radiation Applications Inc., Long Island City, N.Y.** 62C

Reinforced Teflon, dubbed Rulon, features low coefficient of friction, high compressive strength, abrasion and corrosion resistance, and thermal stability from −350 F. to 500 F. It is a material of construction for bearings, washers, gaskets, packings, seals and piston rings. Because it is said to give up to 500 times the wear resistance of Teflon, Rulon is also performing many heavy-duty jobs in textile machinery and in equipment for chemical and food processing, refrigeration, papermaking and others.—**Dixon Corp., Bristol, R.I.** 62D

For more information about any item in this department, circle its code number on the Reader Service Postcard (page 171)

for exacting chemical process operations...

- Screw Feeders
- Liquid Phase Pelletizers
- Metering Pumps
- Plastic Blending Machines
- Cylindrical Dryers
- Rotary Feeder Drives
- Agitator Drives
- Conveyors



For use in hazardous locations, regulation explosion-proof motors with safety-proved pneumatic or electric remote controls are available for use with Cleveland's standard Speed Variator.

CUSTOM MADE CLEVELAND SPEED VARIATOR BED PLATE ASSEMBLIES GIVE PRECISION CONTROL OF INFINITELY VARIABLE SPEED OUTPUT

Now, for the first time Cleveland's *New* Motorized Speed Variator may be engineered into compact, pre-tested drive arrangements for powering your driven equipment in non-hazardous locations. These assemblies are accurately pre-aligned at the factory—require little maintenance, only periodic oil changes.

HERE'S THE COMPLETE STORY:

- Requires only slightly more space than an equally rated standard electric motor
- Provides variable output speeds over 9:1 and 6:1 ranges
- A complete line featuring 5 sizes from ⅓ to 15 HP
- Integral "pancake" style AC radial air gap motors conforming to NEMA design "B" specification
- Provides speed holding accuracy up to 0.1% with uniform loading
- Output speeds smoothly and easily adjusted while operating under load

These versatile mechanical-type drive units are especially applicable for chemical blending operations where it's important to hold fixed speeds. They can be run at definite speed settings for extended periods without localized wear of running parts or freeze-up of speed changing mechanism.

Variator is a true torque converter—provides high torque at low speeds for constant HP applications—gives traction even during periods of extreme overloading.

For complete engineering information on the *New* Cleveland Motorized Speed Variator, write for free, illustrated bulletin Number 275 or contact your Cleveland representative today.

Cleveland Worm & Gear Division
Eaton Manufacturing Company
3273 East 80th Street • Cleveland 4, Ohio

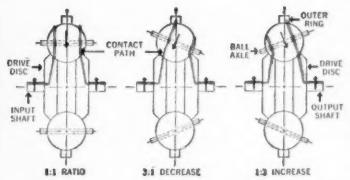
CONTROL VERSATILITY

For manual operation, a hand wheel is mounted on an extension of the control worm and equipped with a turns counter to indicate relative speed settings

For electrical remote - controlled operation, a small single-phase motor drives the worm through chain and sprockets, or enclosed gearing

This pneumatic operator accurately positions the control worm in direct relationship to a 3 to 15-pound air signal

CLEVELAND SPEED VARIATOR



How The Speed Variator Works

Power is transmitted through input shaft to a beveled drive disc in contact with axle-mounted alloy steel drive balls. Input shaft rotation causes balls to rotate about their axles. Power is then transmitted from all rotating balls to output shaft by similar ball-disc contact on the output side. Output speed is determined by relative lengths of contact paths on input and output sides of the balls. By tilting both axles and balls, relative lengths of the two contact paths are varied to give increasing or decreasing ratios as shown on the sketches.

ENCLOSED HORIZONTAL TRAY FILTER WASTES NO SLURRY OR SOLVENT

Designed to recycle slurry or wash liquor from tank to trays, unit permits various operating cycles to produce liquid-free filter cake.

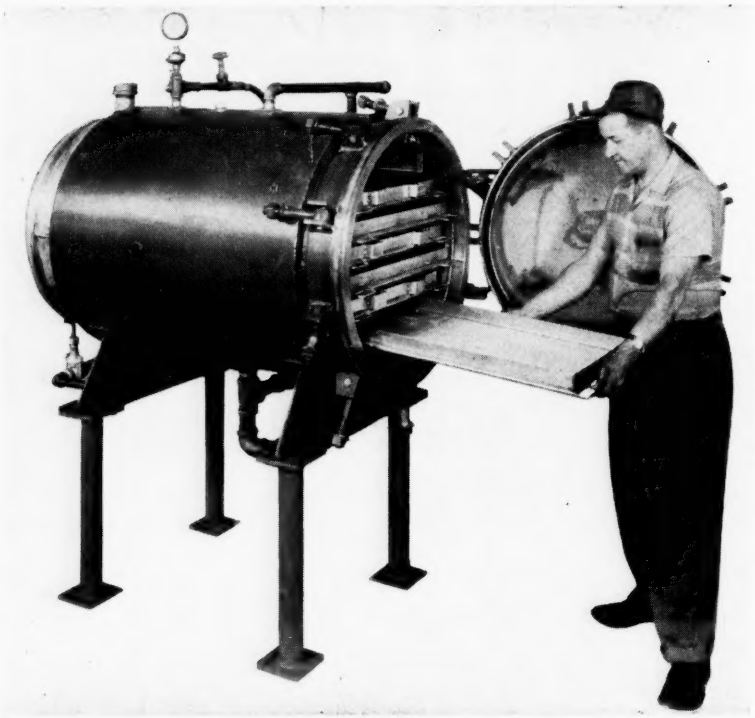
Ingeniously designed, a new horizontal tray filter completely recovers solids and liquids, leaving no liquid heel. The totally enclosed unit can safely handle hazardous materials and solvents.

In small filters, trays may be removed by hand for dumping of filter cake. In large units, the group of trays may be rolled out and rotated mechanically, or rotated inside the tank, to drop cake into a hopper for removal.

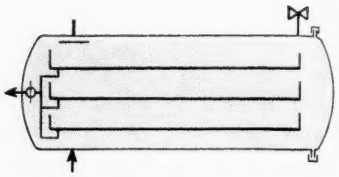
Design of the filter tends to keep the cake evenly distributed on all trays, and also keeps it moist to prevent cracking caused by cake drying faster on one tray than another. Other advantages claimed for the unit:

- Positive - displacement cake washing, with minimum quantities of wash liquid.
- Separation of wash liquid from filtrate, with minimum mixing.
- Recovery of residual solvents, without disturbing filter cake.
- Intermittent filtering possible, without any danger of cake moving.
- Drying of solids in place—under vacuum, if necessary.

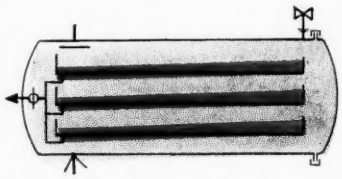
A typical operating cycle is



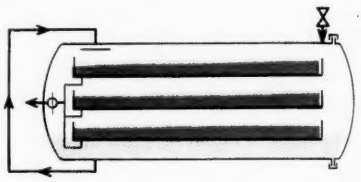
Trays pull out individually for dumping, in small model. Larger unit has trays grouped integrally so all can be handled as one.



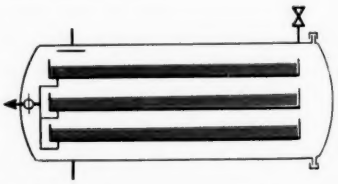
1—Filter is full; vent (on top) is now closed; filtering begins.



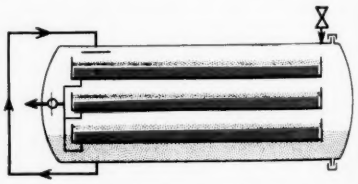
2—Filtering is about one-third completed; cake forms on trays.



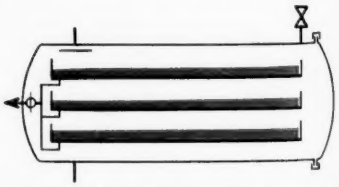
3—Slurry flow is reversed; liquid heel drops; cake is flooded.



4—Mother liquor is purged by gas; excess liquid is driven from cake.



5—Predetermined quantity of liquid washes cake; wash can be repeated.



6—Cake is blown down with air or gas to remove final wash liquid.

PLATINUM POINTS THE WAY TO LOWER COSTS

The low cost of platinum is real, because of its long life, high recovery rate and scrap value (once you have purchased platinum, you have it almost forever).

LONG LIFE—it is almost indestructible, even in the most difficult environment.

EXCELLENT RECOVERY—most of the original metal is easily recovered, even after years of use.

HIGH SCRAP VALUE—the dollar value of recovered scrap is almost as great as the original metal cost.

When you need Platinum, take advantage of BISHOP'S long experience (. . . since 1842), ample supply . . . broad capabilities:

- FORMS—foil, gauze, plate, sheet, strip, tubing
- WIRE—pure, commercial, composite, thermocouple
- LABORATORY APPARATUS
- CLADS AND BIMETALLICS
- CHEMICALS
- CATALYST RECOVERY
- SCRAP CONVERSION

For the full story, write for Bulletin P-6.

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briefly illustrated, but the mechanism will be described in full to better depict the various sequences that are possible.

▶ **Design Features**—The filter consists of a horizontal tank containing a series of trays or pans stacked vertically. The trays have false bottoms and are furnished with a screen that acts either as the filter medium or as a support for filter cloth or paper.

Each of the trays is also provided with a standpipe that extends to a desired height above the top of the filtering element, and opens to the tray immediately below or to the bottom of the tank, as the case may be.

Piping for the unit is arranged so liquid may be transferred from the bottom of the tank to the top tray (and to the others by overflow through the standpipes) to finish off any liquid heel.

▶ **How It Works**—Slurry is pumped into the empty unit while air is vented, until tank is full. The vent is closed and filtering begins, with the pressure of incoming slurry providing the impetus. The unit can handle a slurry volume larger than the tank capacity depending on the amount of solids to be removed.

When all of the batch is in the tank and the trays are almost full, the feed line is shut off and air or gas pressure is applied to the tank simultaneously with the opening of the recirculating line. All the slurry remaining in the tank is gradually displaced by recirculation—into the top tray and by overflow to the lower trays—until no liquid remains in the filter.

At this point, gas is blown through the cake to completely purge the mother liquor, then wash liquor is pumped into the tank and distributed to the trays via the recirculation system. Wash cycles may be repeated as necessary, with the wash liquor being recovered independently of the filtrate if desired.

▶ **Shake the Cake**—The cake is dried with more gas, then removed in various ways depending on the size and complexity of the unit.

In small filters, trays are usually withdrawn individually and dumped manually. In large ones, they are constructed as an integral group that may be rolled out, rotated 180 degrees and shaken or vibrated to discharge cake, which falls onto tray bottoms. When the trays are rotated back 90 degrees, the cake drops off.

In any size unit, the rotation cycle just explained may be carried out inside the unit without exposing the cake to the atmosphere. Here, the cake drops into a cake hopper for removal by reslurrying or by a conveyor.—**T. Shriver & Co., Harrison, N.J. 64A**

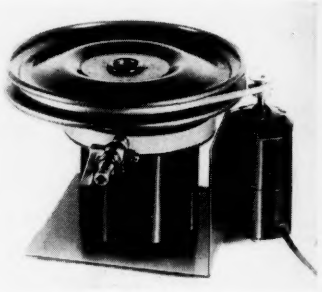
For more information about any item in this department, circle its code number on the Reader Service Postcard (Page 171)

Hand pump

Self-priming unit is very resistant to a variety of corrosive fluids.

Molded of polyvinyl chloride, with Hypalon and polyethylene valves, a hand pump for transferring corrosive liquids provides fast flow with little pumping effort.

Virtually leakproof, the pump is available in sizes to move a gallon in 4, 6 or 9 strokes. Typically used for transferring material from drums and carboys, the unit comes with a special adapter for new-style polyethylene carboys, and with extra hose lengths as desired. —**Beckson Mfg., Inc., Bridgeport, Conn. 66A**



Vacuum pump

Two-stage evacuating system has fewer moving parts than most.

Pulling vacuums down to 0.15 mm. Hg, a two-stage rotary vacuum pump has less moving parts than conventional ones. Said to be low in cost because of its design simplicity, the 11-lb. pump is portable, runs on 115-v. power.

Called the V-2, the unit can be used for classroom demonstration of physical principles, or industrially where several small vacuum systems are more convenient than a large one.—**Atomic Laboratories, Inc., Berkeley, Calif. 66B**

Infrared pyrometer

High sensitivity and fast response allow stationary or moving targets.

A compact pyrometer no larger than a hand movie camera can measure and control the temperature of any size object, whether the target is stationary or moving at various speeds.

It is particularly suited for surfaces that do not permit physical contact, moving objects and tiny targets, high-speed measurement, and measurements in hazardous, noxious or other adverse environments.

Detector and control unit are mounted in a single package for

What's News in Enjay Chemicals...

firsts

ISOPROPYL ALCOHOL
ISOOCTYL ALCOHOL
DECYL ALCOHOL
TRIDECYL ALCOHOL

Since introducing isopropyl alcohol in the early "twenties," Enjay has pioneered in the development and production of many advanced chemical raw materials for industry.

In the field of alcohols, hexyl alcohol is the latest in a long line of Enjay "firsts" designed to meet the changing requirements of our customers. This new oxo alcohol is offered for quick, dependable delivery from conveniently located supply points.

Next time you need alcohols or other chemical raw materials, be sure to call on Enjay. For more information, write to Enjay at 15 West 51st Street, New York 19, N. Y.

SPECIFICATIONS OF ENJAY HEXYL ALCOHOL

Purity (wt per cent) min	98.0
Specific Gravity (20/20°C) min	0.819
Specific Gravity (20/20°C) max	0.821
Acidity, as acetic acid (wt per cent) max.	0.001
Color (Pt-Co) max	10
Water (wt per cent) max	0.10
Carbonyl Number (mg KOH/g) max	0.2
Distillation (°C)	
Initial min	149
Dry Point max	156
Appearance: Clear and Free of Suspended Matter	

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ENJAY CHEMICAL COMPANY

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ENJAY

those applications that require unitized equipment; where limited detector-head mounting space exists, control unit and detector may be separated for remote measurements.—**Servo Corp. of America, Hicksville, N. Y.** 66C

Check valve

Backflow eliminated, gas contamination prevented, in regulators.

Operating with a low cracking pressure, a reverse-flow check valve operates on all commercial gases, preventing their contamination in regulators. The unit prevents: accidental mixing of combustible gases with oxygen, reverse flow when mixing gases, and back suction on exhausted cylinders.

Models designed for regulators are installed by simply replacing the outlet nipple. The valve fits all makes of line and cylinder regulators.—**The Harris Calorific Co., Cleveland.** 68A

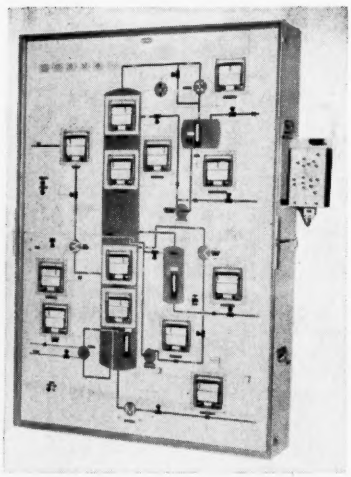
Zone refiner

Horizontal attachment increases versatility of basic instrument.

Work on semiconductor and thermoelectric materials, as well as on ultrapure metals, is facilitated by a horizontal zone-refining attachment on an instrument that already performs floating zone refining and crystal growing.

The attachment mounts on the original basic unit, consists of a quartz tube mounted on end supports that are attached to a carriage that moves the tube through a stationary induction coil. The end supports provide gas seals and a means for introduction and exit of gases.

To change from floating-zone operation to horizontal-zone refining to crystal growing requires less than half an hour.—**Lepel High Frequency Laboratories, Inc., New York.** 68B



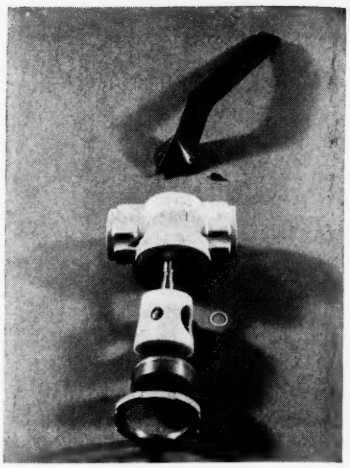
Control panel simulator

Train personnel without endangering man or valuable equipment.

All phases of fractionation-column control can be explored and practiced with a new device that simulates actual operating conditions. It looks and behaves like an ordinary control panel, but the dials and gages are operated by a remote-control console.

In operation, an instructor simulates realistic changes in conditions, i.e., loss of pressure or excess temperature such as might occur during startup, shutdown or emergency situations. The trainee then takes corrective action on the panel—if he goes wrong, an alarm sounds.

Biggest advantage of the unit is that emergency conditions and their correction can be explored in safety; on real equipment, potentially dangerous situations can rarely be explored during operator training.—**Carmody Corp., Buffalo.** 68C



Ball valve

Molded Teflon capsule surrounds ball, provides renewable seal.

Separate O-ring seals are replaced by a conical-shaped Teflon capsule that is molded around the ball in this valve. Sealing adjustments can be made in the line without shutdown, according to the manufacturer.

Factors that make the valve easy to adjust, maintain and overhaul are the capsule and a screw-in base plate. As the base plate is tightened, it pushes on the Teflon, which cold-flows toward the area of least resistance, pressing more closely to the ball to effect a tighter seal.

Available from ⅛ to 2-in., the valve has a working-pressure range of full vacuum to 1,440 psi., comes in ductile iron, steel, bronze, aluminum and several stainless steel alloys.—**W-K-M Div., ACF Industries, Inc., Houston.** 68D

Baffled cold trap

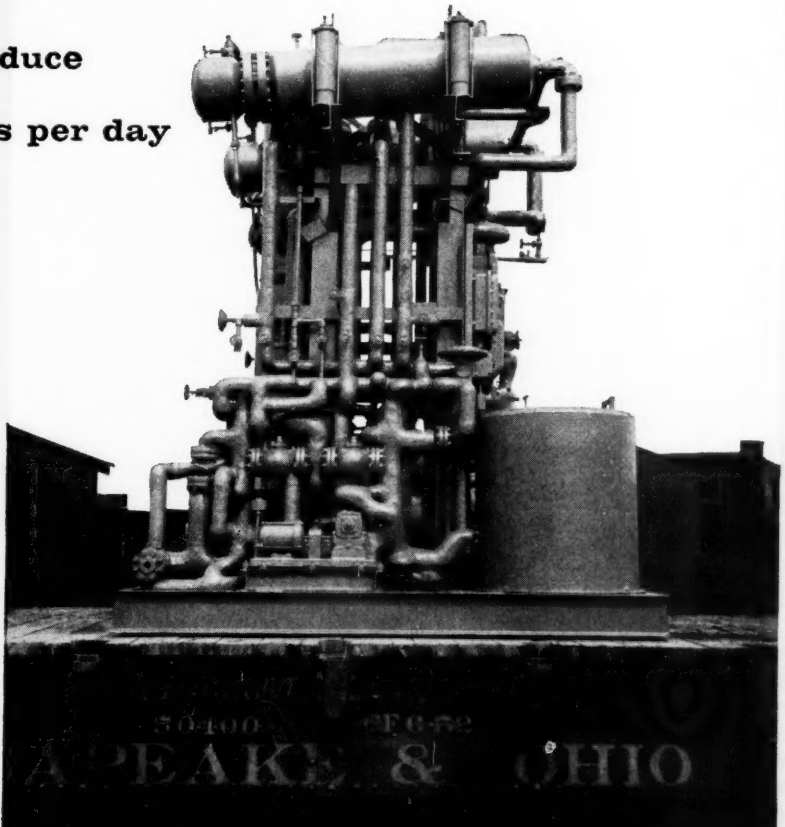
Coolant reservoir in unit's center furnishes a uniform environment.

Vacuum pumping systems can benefit from an optical baffle-cold trap featuring a centrally located coolant reservoir that acts to cool the chevron baffle plates evenly and uniformly.

The units are optically opaque—

New Equipment continues on page 156

NEW COMPACT GIRDLER HYDROGEN SULFIDE UNITS produce from 1 to 5 tons per day economically!



Solves the need for hydrogen sulfide gas in quantities not practical to handle by cylinders Girdler can now offer you low cost compact hydrogen sulfide package units with capacities from 1 to 5 tons per day. The small unit will produce up to 2000 pounds per day, and a larger unit produces from 2000 to 10,000 pounds per day. They will also operate efficiently and economically at a fraction of their rated capacities.

They utilize a simple new Girdler process based on the reaction of hydrogen with liquid sulfur at elevated temperature and pressure to produce hydrogen sulfide gas. The complete units are fabricated at Girdler's shop and are shipped partially assembled on skids with a minimum of work to be done at the plant site. Operating requirements include hydrogen, liquid sulfur, electric power, steam, and cooling water.

Write for full information on new Girdler Hydrogen Sulfide compact Units today. Take advantage of Girdler's know-how and proven experience in the field of high-temperature, high-pressure processing plants.

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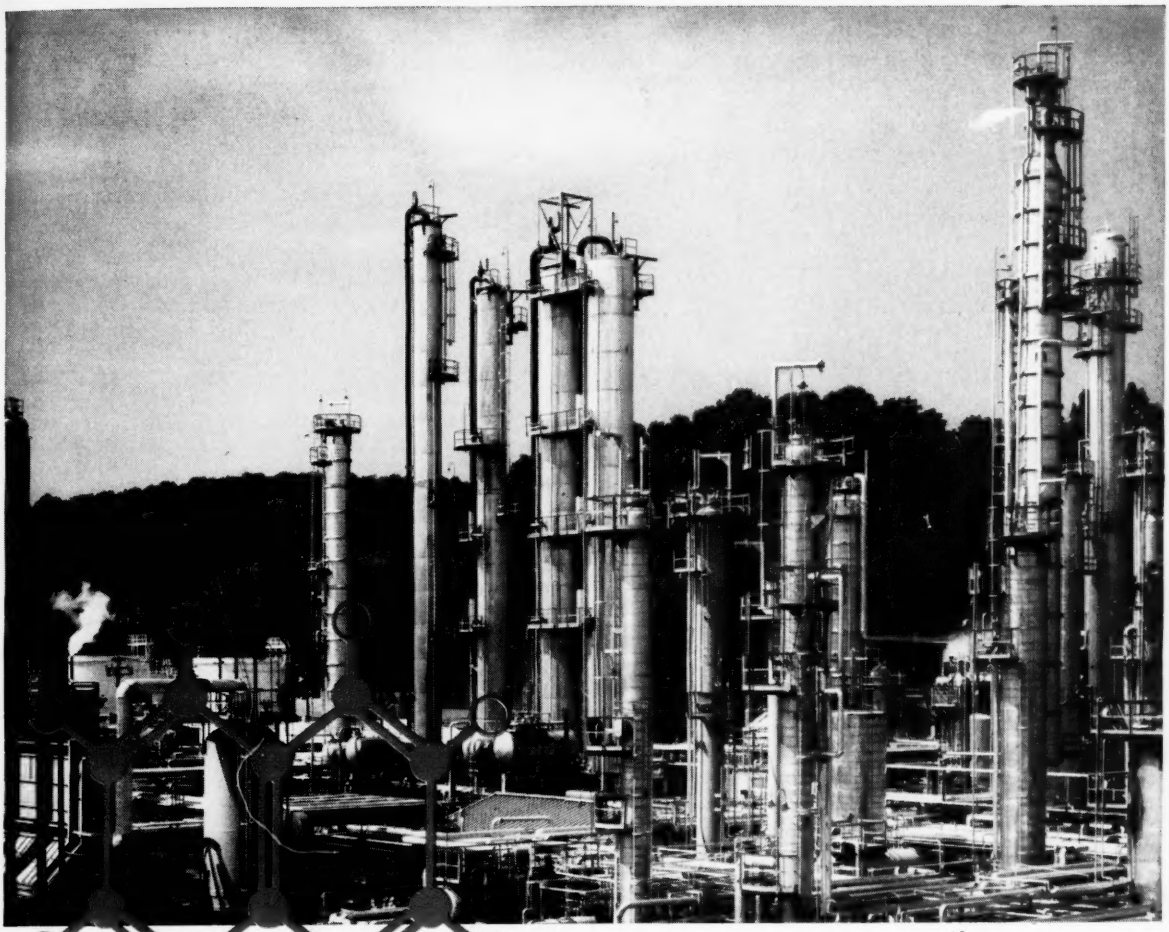

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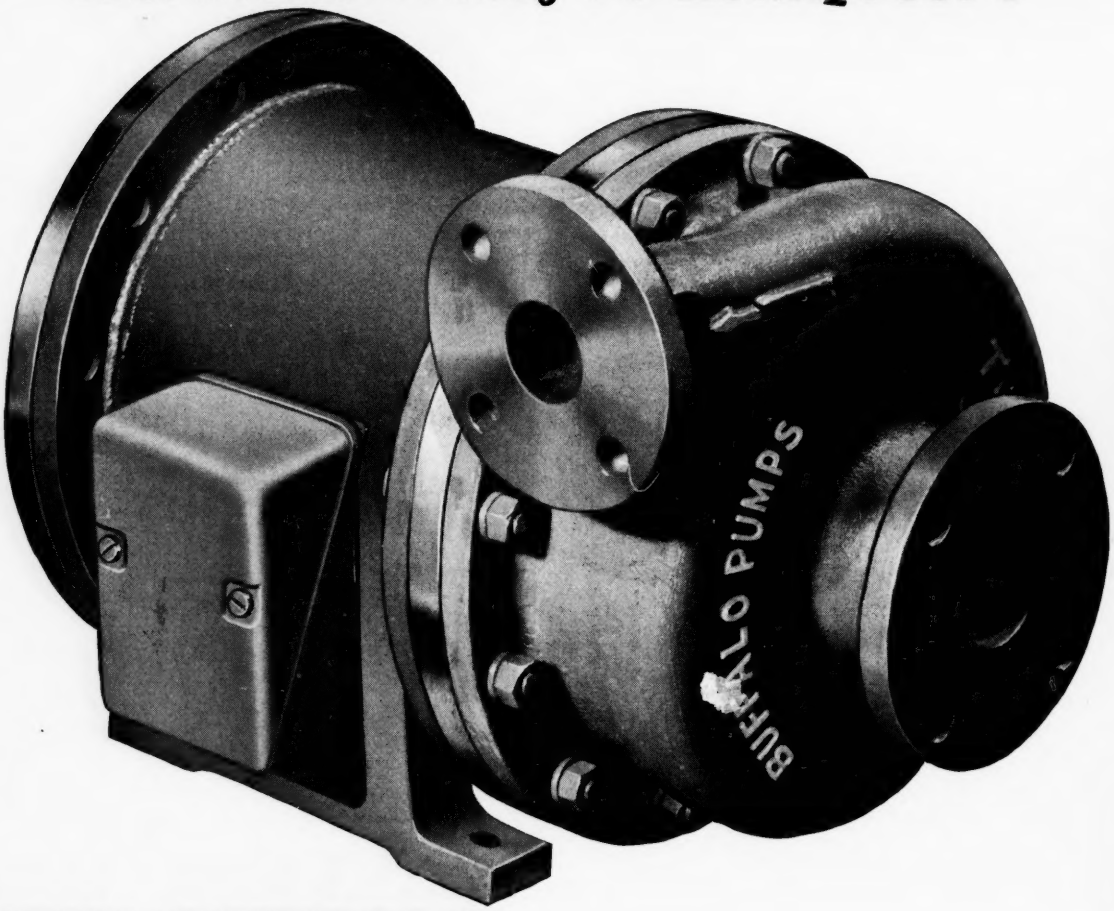

NEW 'BUFFALO'

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with self-adjusting bearings

Now, from Buffalo Pumps, a leakproof line of totally enclosed hermetic pumps so simple in design they can be taken apart and re-assembled with open-end wrenches and a screwdriver.

Designed for the chemical, petrochemical, atomic energy, and marine industries, the new Can-O-Matic's are the most practical, durable and easily maintained pumps in the hermetic field.

Long-life bearings represent a great new advance in canned pump design. Lubricated by the liquid being pumped, they absorb both radial and axial thrusts...automatically compensate for bearing and journal wear. Toxic or volatile, liquids cannot escape...air cannot leak in.

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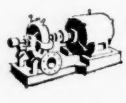

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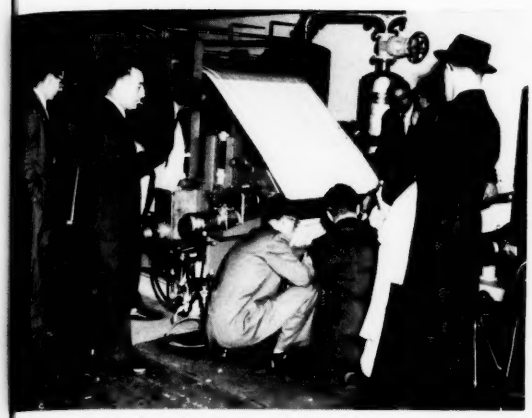

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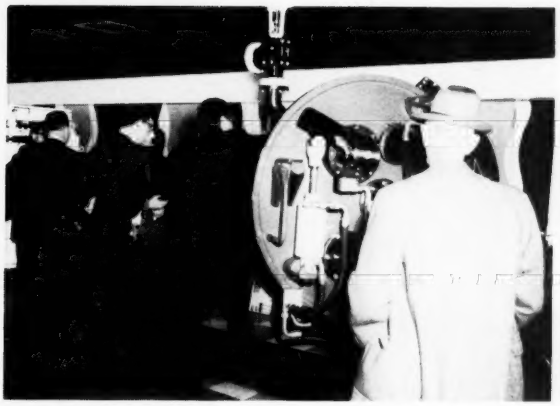

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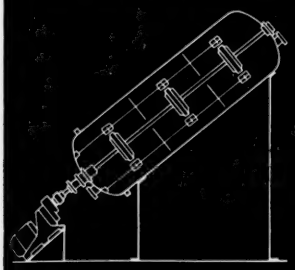

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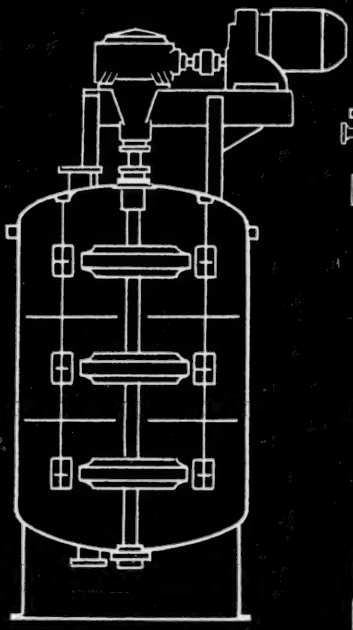

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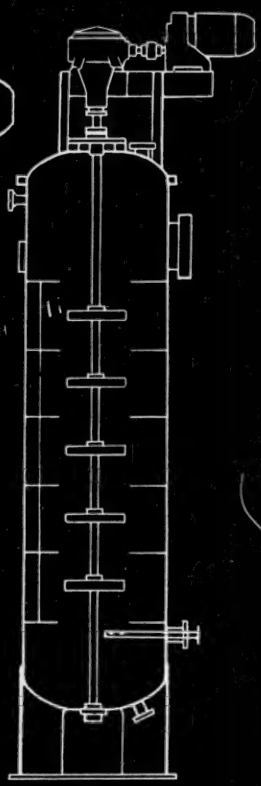

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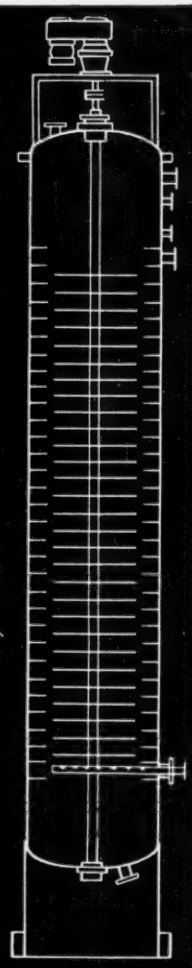

4

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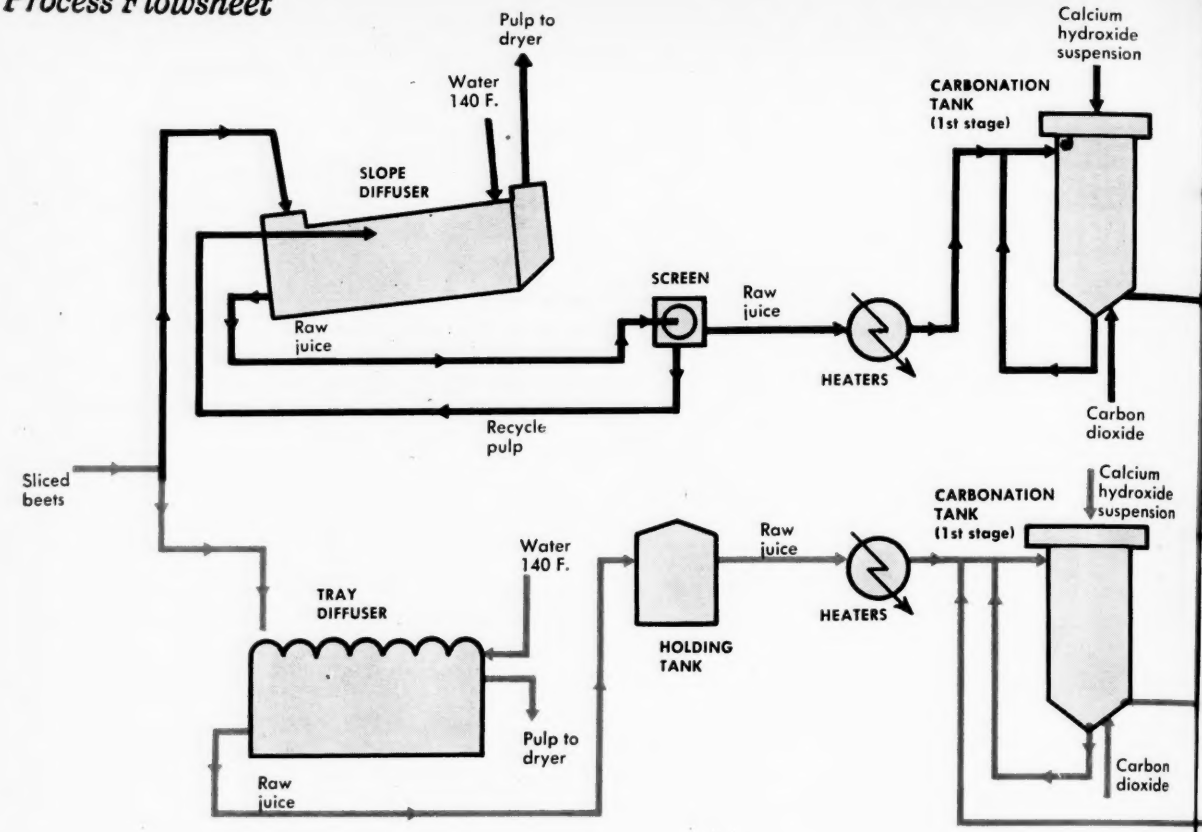
Process Flowsheet



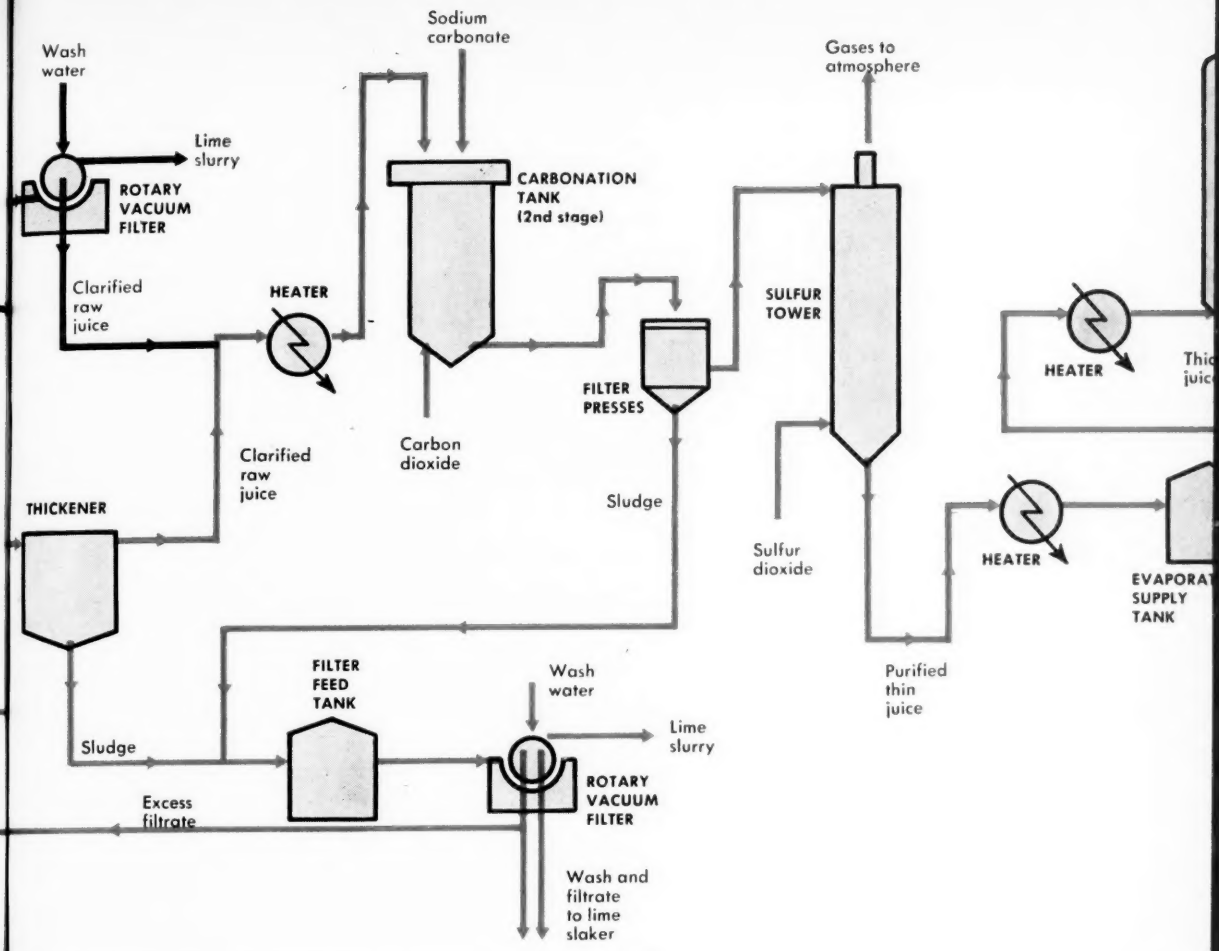
Unfold flowsheet

Beet Sugar: A Radical New Look

A simple but tricky concept—intermediate storage of sugar-bearing juice—is the big feature among many that Holly Sugar Corp. has built into its modernized sugar facility in California's Imperial Valley.

C. R. HAVIGHORST,
McGraw-Hill World News: Los Angeles

New semispheroidal tanks, with combined capacity of 9.2 million gal., hold intermediate sugar-bearing juice.



A newly modernized plant of Holly Sugar Corp. at Brawley, Calif., boasts improvements that show beet sugar technology to be anything but static; and features a radical innovation that may well become standard among other producers.

In view of U.S. sugar outlook, Holly's timing is appropriate (though coincidental). Beet-sugar firms haven't yet moved toward grandiose expansions, but world tensions clearly underline the significance of fully domestic beet processing as a reliable sugar source.

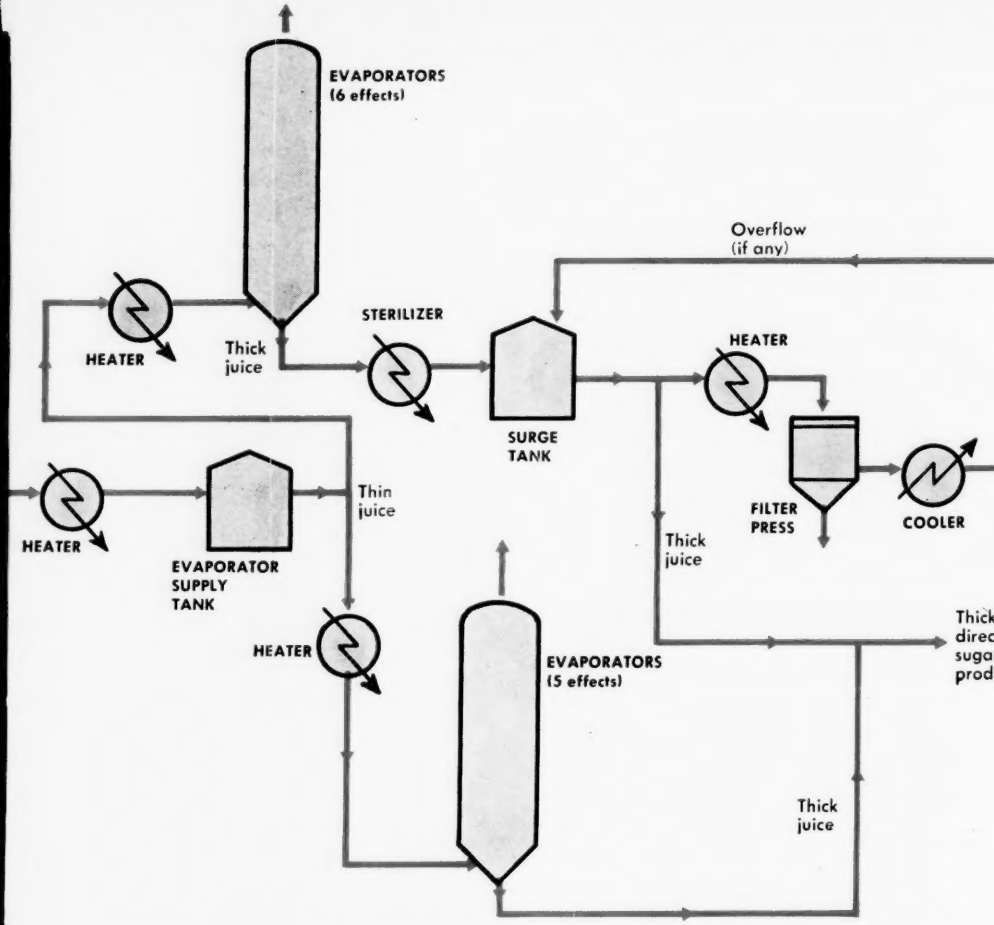
▶ **What's New** — Holly's innovation is elegantly simple. Heretofore, producers in California's Imperial Valley have operated only during beet harvest, because beets cannot be stored in warm climate. Holly has changed this by achieving workable storage of intermediate "thick juice." Now, only the beet-processing part of the plant—the part described here—is tied to the 110-day harvest; actual sugar production is spread over an additional 30-35 days.

Key to this increase is careful juice handling, and use of five specially designed, semispheroidal tanks having combined capacity over 9.2 million gal. Result: plant's 1961 sugar output is pegged at 142 million lb. instead of the 98.5 million lb. that would have resulted without the tanks—with no significant labor increase and at only 40% the cost of gaining the added capacity through a new conventional plant for 2,400 tons/day of beets.

The other modernizations, though less dramatic, have streamlined operations. Except for installing some bigger equipment, Holly has left its original operation intact, and the process changes are found in new, parallel trains of process flow.

▶ **Through the Plant**—First steps of beet processing are to leach sugar from beet slices, treat the produced raw juice to take out colloidal impurities, and separate juice from the resulting slurry.

At Brawley, about 65% of the beet feed undergoes these steps in conventional facilities not added during modernization: a continuous, tray-type diffuser, juice heaters, a first-stage carbonation tank and a multicompartment thickener.



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The other 35% of the feed, some 2,400 tons/day, is leached by 140 F. water in a continuous, countercurrent slope-diffuser that yields 455 gal./min. raw juice. Latter passes through a screen and a heater to a carbonation tank, where it is treated with 72 gal./min. calcium hydroxide slurry and 4,460 lb./hr. carbon dioxide.

Separating the tank effluent represents another innovation—instead of going to a thickener, the stream enters a vacuum filter designed for high flow rate.

▶ **Recombine**—Clarified juice joins the stream from the thickener. Combined flow is heated and goes to a second carbonation step, where sodium carbonate precipitates more impurities.

A filter press removes solids, and the juice goes to a tower where it is treated by sulfur dioxide. This bleaches the solution, completes purification and adjusts pH. Bleached stream is heated, goes to an evaporator supply tank.

Here the flow splits again. Roughly 65% is heated to 208 F., then concentrated to about 60%

sugar in a five
goes directly t
▶ **To the Tank**
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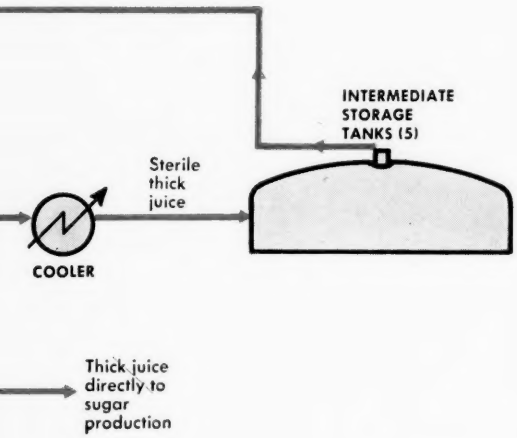

gar in a five-effect vacuum evaporator. Product
es directly to sugar processing.

To the Tanks—A six-effect evaporator concen-
tes the rest to about 70% sugar, and the con-
ntrate is then heat-sterilized. Part of the sterile
ution bleeds directly to sugar production; the
t is filtered at 194 F., cooled to 104 F. and sent
the new tanks.

Preparation and operation of these tanks
ow the care needed for successful juice storage.
fore they were placed in service, their interior
faces were sand-blasted and triple-coated with
epoxy resin; exteriors were painted aluminum
reflect solar heat.

Operators clean and sterilize the vessels be-
e introducing thick juice. Tanks are filled, leav-
no head space. Overflow goes to a smaller,
mmon tank, and returns immediately to process-
. Any air inhaled by the tanks passes first
ough an electrostatic precipitator that removes
res, yeast and dust. Quality of the juice in stor-
is checked daily.

M
P

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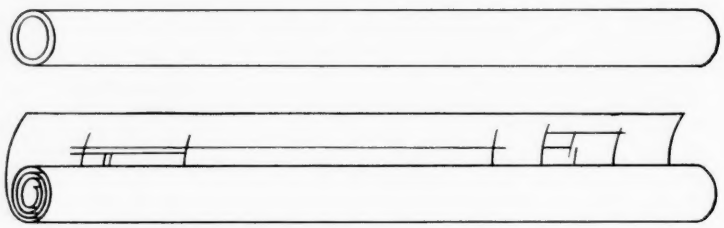

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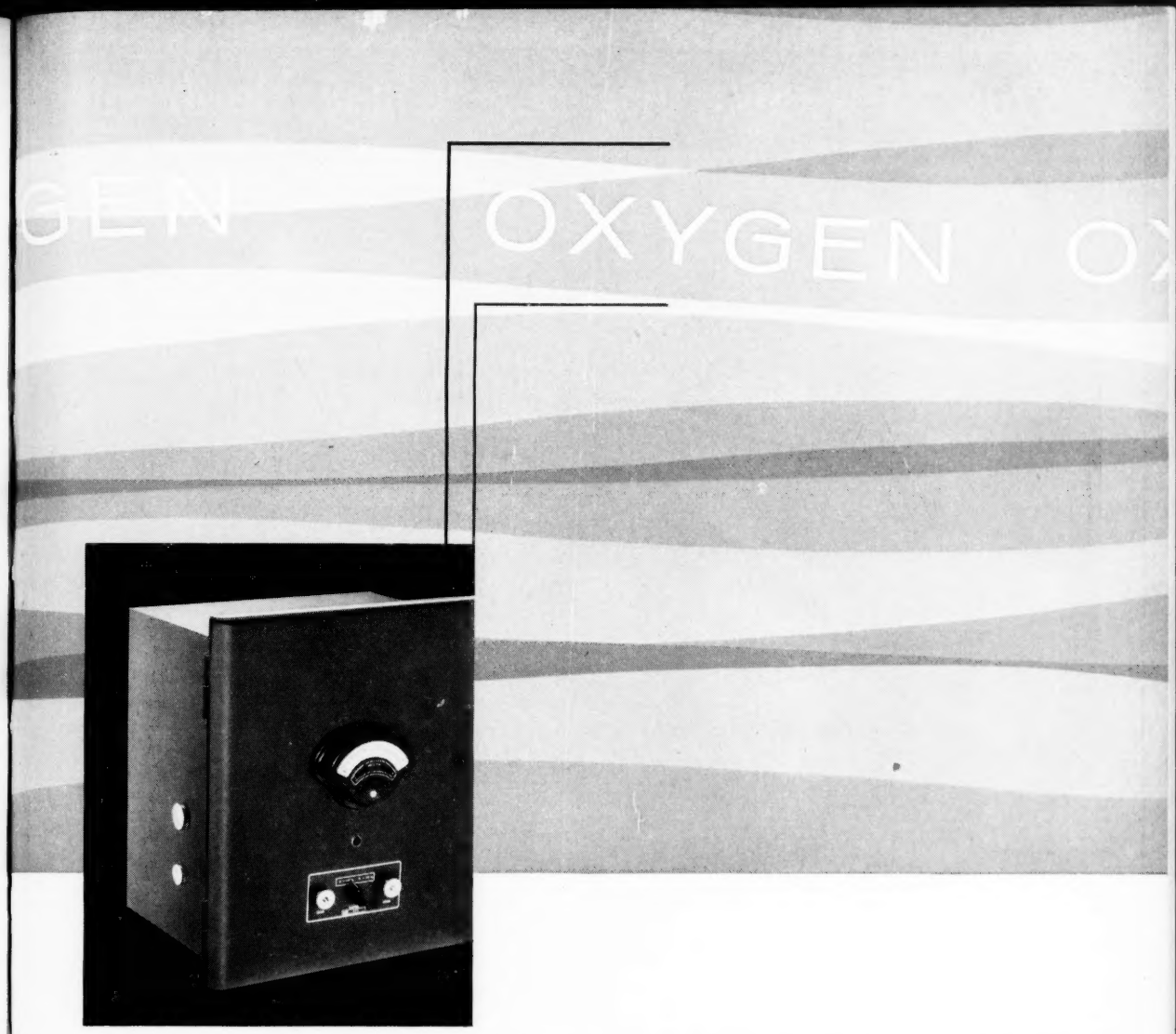

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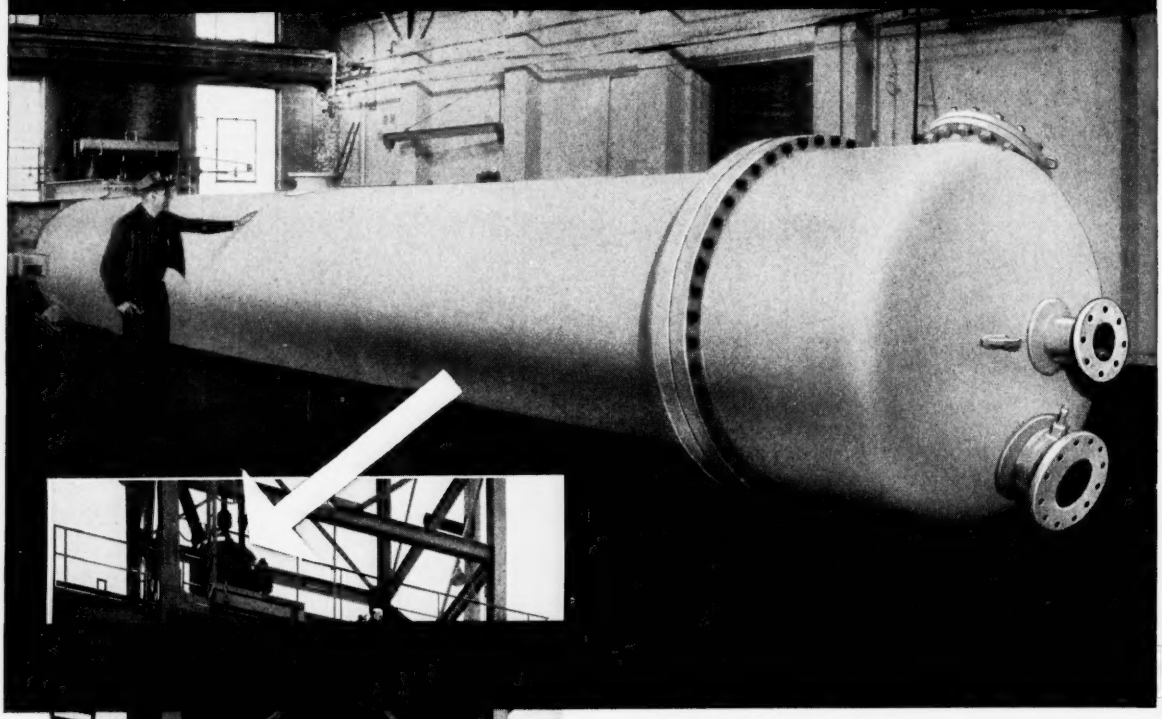

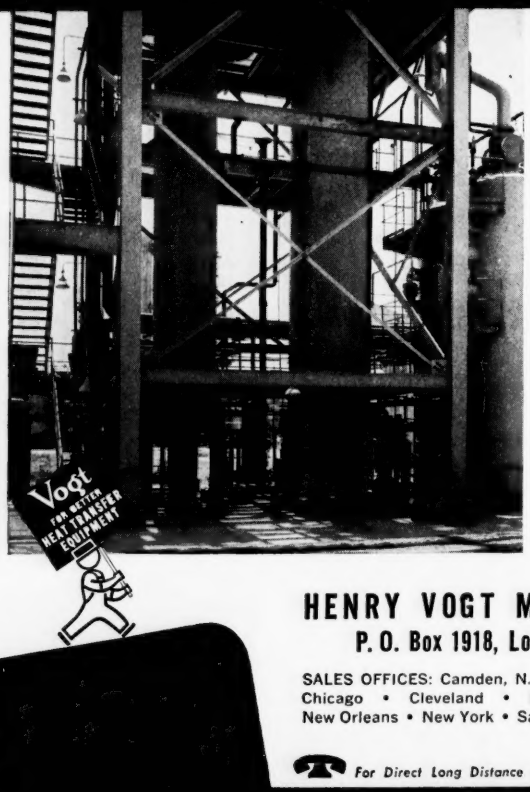

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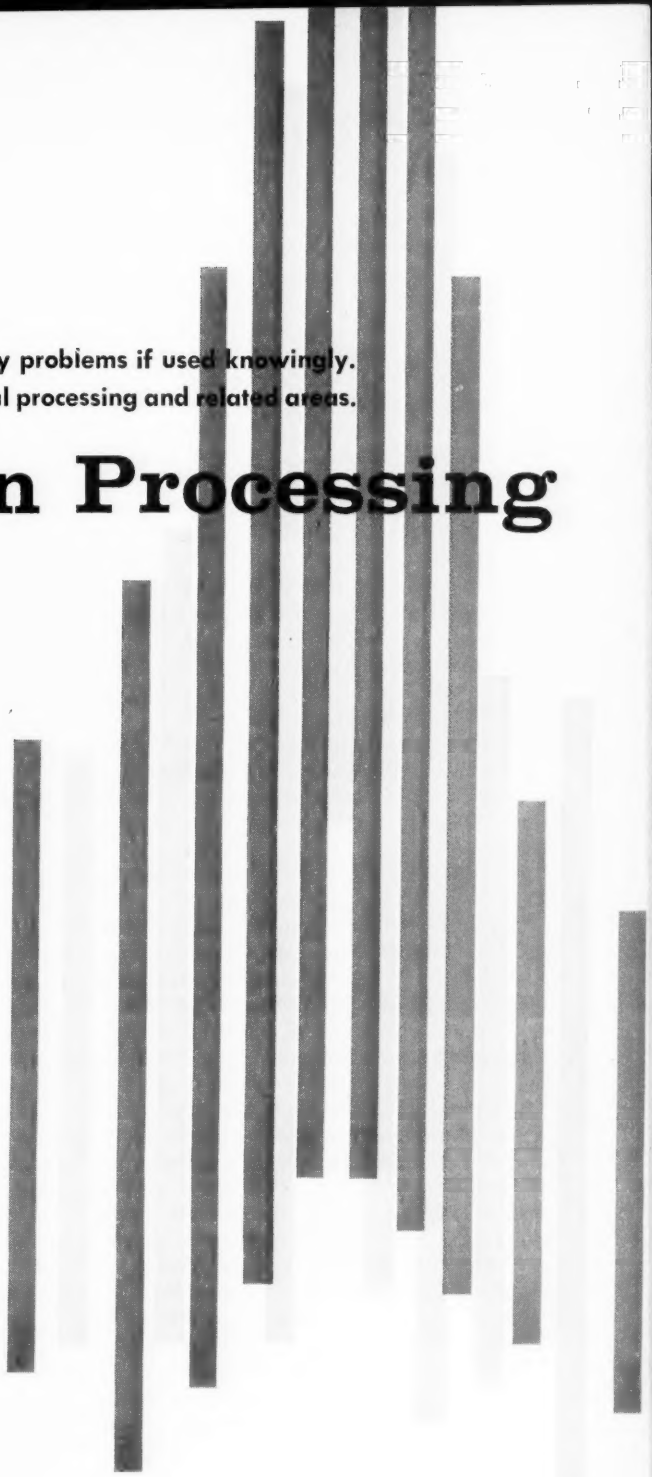
HEAT TRANSFER EQUIPMENT

A CE REPORT

Acoustic energy in gaseous media can solve many problems if used knowingly. Here's an evaluation of what it can do in chemical processing and related areas.

Ultrasonics in Processing



R. M. G. BOUCHER, *New York University*

In the late nineteenth century, Kundt showed that fine, invisible particles could be agglomerated at the nodal point of a sound wave, and thus be rendered visable. This was probably the first demonstration of the potentialities of sonic and ultrasonic precipitation.

Application of this technique to industrial processing did not follow for many years, mainly because little work was done on developing powerful, highly efficient sonic generators. However, some big strides have recently been made, and more will undoubtedly follow.

As the reader will see, sonics and ultrasonics already offer practical advantages in drying heat-sensitive powders and fibers, in increasing the efficiency of various types of gas-cleaning equipment, and in controlling foams. Furthermore, the technique may play an important part in rocket propulsion. And if the expected improvements in sonic generators materialize, the gas precipitation plants that became so fashionable in the U.S. for a brief period in the 1940's *may stage a comeback—and this time their economic justification will be sound.*

The acoustic technique may well find other processing applications. For instance, advanced research projects are under way to evaluate its potentials in heat and mass transfer (see Chem. Eng., *May* 15, 1961, *p.* 171), *isotope separation, ultrasonic burning, and distillation.*

It would be difficult to cover all these areas in one report, and we will therefore confine our survey to those that currently present the process engineer with the most promising fields of application—gas cleaning, defoaming, drying and rocket thrust modulation.

Today, it would certainly be a gross mistake for the engineer to underestimate the possibilities of airborne ultrasonics. This report will try to help him by examining drawbacks as well as benefits, and by separating the wheat from the chaff in evaluating the economic potential of this technique.

PART I—AEROSOL PRECIPITATION

What Can Ultrasonics Do?

American engineers will certainly remember the "ultrasonic craze" that spread over this country in the late forties. At that time, it seemed to be a must for any smart engineer to use high-intensity sound for his fume and aerosol disposal problems. Pictures of ultrasonic dust precipitators were displayed in all kinds of commercial and technical magazines, with fantastically optimistic figures for both output and energy consumption.

What actually came from all this noise (quite audible, in this case) about airborne ultrasonics?

Actually, this hasty and overenthusiastic propaganda almost killed the development of the acoustic precipitation technique. To our knowledge, none of the ultrasonic dust precipitation plants built in the U. S. shortly after the second World War are still in operation. This great failure has certainly left a bad impression among American industrialists and gas cleaning specialists, but, fortunately, it did not strike a deadly blow abroad.

There, extensive studies have led to numerous improvements in the design of sound generators. Much pilot-plant information has been accumulated, and some of this has been applied to large-scale installations.

While the energy consumption of most of these installations still leaves something to be desired, they do have the ability to handle even very small particles and to operate over a wide temperature range. The investment cost is lower than for other types of precipitating equipment. Certainly high power consumption is a drawback, but at least one recently designed sound generator promises to bring power and maintenance costs down to more-favorable levels.

Later on, we will call attention to one area where power consumption presents no problem even now—the use of ultrasonics to increase the efficiency of conventional gas-cleaning equipment, such as cyclones, mesh-arrestors and venturi scrubbers.

Before going further, let us define expressions such as sonics, ultrasonics, airborne sounds or airborne ultrasonics. In this report, these expressions cover acoustic waves in general, whether audible or inaudible, emitted in any kind of gaseous medium.

While the term "ultrasonic" should refer only to sounds beyond the average range of human hearing, unfortunately it is common practice to use it without this restriction in aerosol and fume precipitation literature.

Classically defined, an airborne sound wave is a compression wave followed by a rarefaction wave traveling in an elastic gaseous medium. The outstanding characteristics of these pressure fluctuations are their magnitude (or intensity) and the frequency with which they occur.

If transmitted through a gaseous medium containing fine particles in suspension—in other words, an aerosol—the acoustic waves will produce a strong turbulence that, in turn, will create impingements and agglomerations between suspended corpuscles. This is the principle on which all industrial sonic agglomerators are based.

The ultrasonic technique can be applied, at least in principle, to many areas in the field of air pollution, gas cleaning and product recovery. Among the most promising from a practical standpoint are the following:

1. Precipitation of corrosive aerosols, such as gas streams containing H_2SO_4 mist, HNO_3, H_3PO_4 and alkalis.
2. Precipitation of phthalic anhydride, carbon black, and calcium carbide.
3. Recovery of soda ash dust from black liquor in paper industry; recovery of cement dust and tar mist.
4. Treating of fumes from electric furnaces in metallurgical industries.
5. Cleaning of blast furnace gases.
6. Treating of effluents from petroleum refineries.
7. Precipitation of furnace dust and dissolution of SO_2 in power station operations.

In this paper, we want to emphasize the engineering aspects of the ultrasonic precipitation technique—we won't dwell on the fundamental mechanisms involved in sonic agglomeration. These have been described in detail in numerous papers.[1-6]

What Is an Ultrasonic Precipitator?

Most of the present acoustic precipitation plants include a tower (often called agglomeration chamber), in which the aerosols are held for several seconds in an intense standing-waves field, and a cheap type of collector (cyclone, gas-washer, or the like), which extracts the flocs formed in the tower. The path between the exit of the agglomeration chamber and the final collector must be as short as possible to avoid the destruction of the agglomerated particles.

In most cases, the agglomeration tower operates in a vertical position, with the sound generator at the top of the column. Final recovery can be carried out dry, by using multicyclones or filters, or wet, by washing in an appropriate liquid.

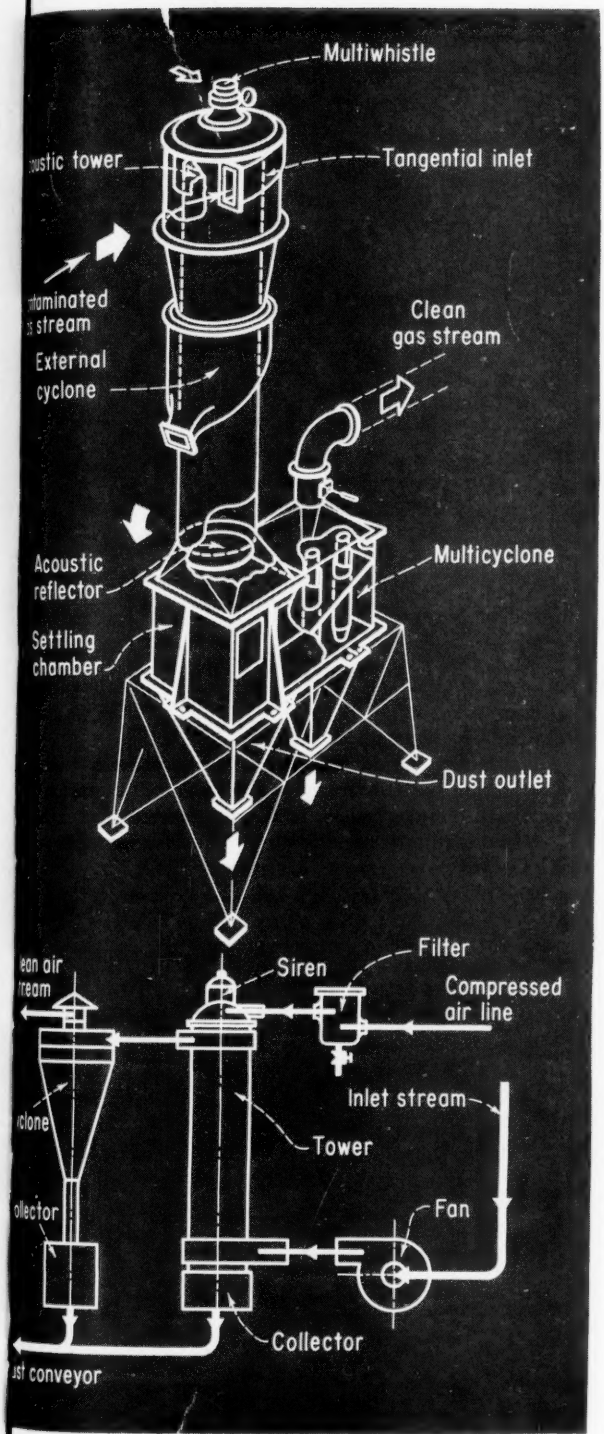
Fig. 1 gives an idea of two different setups at the pilot-plant stage.

The two most important factors that influence precipitation are the characteristics of the sound generator and the general design of the installation.

Let's first consider various types of sound generators. Their characteristics are of interest whether we use them to do most of the precipitating, or merely as a supplement to conventional equipment.

Types of Sonic Generators

High-power acoustic waves can be produced in gases by either static generators (whistles) or dynamic generators (sirens). In the whistle technique, high-speed gas jets are directed at an obstacle or into a resonance chamber, thereby creating intense edge tones or oscillations of relaxation.



Acoustic gas-cleaning pilot plant (top) includes a precyclone to remove the largest particles, and has the acoustic emission directed in the same direction as the aerosol flow-stream. In the plant below it, the emission is counter current.—(Fig. 1)

In the siren method, a perforated rotor driven at high speed (8,000 to 20,000 rpm.) successively uncovers numerous small holes in a stator of circular shape. The series of successive expansions of the compressed gas through these openings makes it possible to obtain an intense acoustic wave. The emission frequency is determined by the number of revolutions per second multiplied by the number of peripheral ports. For most of these rotative sirens, the frequency falls between 1.5 and 25 kc.

Numerous authors have also described laboratory precipitators that use piezo-electric quartz or ceramics, or magnetostrictive or electromagnetic generators, as sound sources. But to date the high cost and rather poor reliability of these devices have prevented them from finding large-scale industrial use. We, therefore, shall not consider them further in this paper.

Static Generators (Whistles)

This first category of generators is based on four main types of mechanical designs.

Fig. 2 shows the schematics of these different air jet generators. The oldest one, developed by Galton,[7] (Fig. 2a) dates from 1883. It consists essentially of a small cylindrical cavity positioned opposite a circular jet through which issues a high-velocity gas stream. The depth of this cavity and its distance from the gas jet can be varied by means of micrometers.

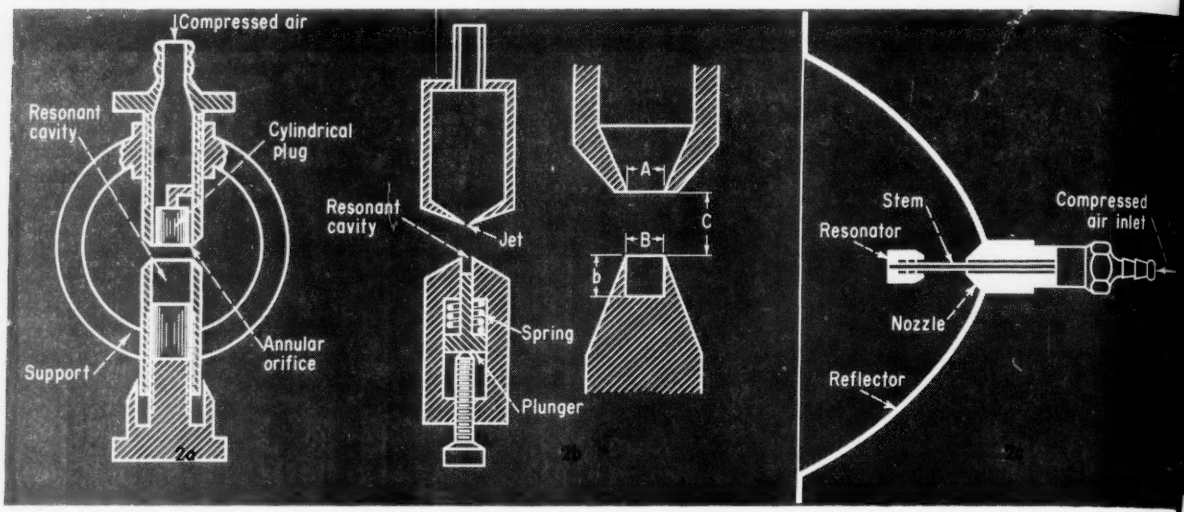
The gas jet impinges against the lip of the resonator and sets up in vibration the mass of gas contained in the resonant cavity. By properly adjusting the depth of the cavity, we obtain edge-tone amplification. This whistle has produced very high and pure frequencies (up to 170 kc.), but the acoustic output has always been very poor. For power applications, this kind of whistle is hence unsuitable.

Fig. 2b shows the classic Hartmann[8] whistle developed in Denmark during the first World War. It consists essentially of a cone-shaped jet nozzle and a coaxial oscillator facing it. The compressed gas feeding the nozzle expands at the exit of the convergent throat at a supersonic speed. If the head of the oscillator is located in the region known as the "pile-up-region" (zone of increasing static pressures), oscillations of relaxation are set up. The cavity periodically fills up with gas at a superpressure, which is then expelled.

This kind of whistle reaches an efficiency up to 6% and sometimes radiates up to 150 w. (The efficiency is considered to be the output in acoustic watts divided by the input in energy watts.)

The frequency and intensity of the emissions of such a whistle depend both on the mass of gas flowing through the nozzle and on the geometrical characteristics of the apparatus—the nozzle aperture A, distance C between nozzle and resonator, opening B of the resonator and its depth b.

Hartmann and co-workers[9] paid particular attention to systems satisfying the equality $A = b = B$. They were able to establish experimentally verified formulas



that gave the wave lengths λ_0 at the entrance of the pile-up region and the corresponding radiated acoustic power I_0:

$$\lambda_0 = 5.8B \text{ (mm.)}$$
$$I_0 = 3B^2\sqrt{P - 0.9} \text{ (w., mm., atm.)}.$$

P is the effective reservoir-pressure, in atmospheres.

In recent years, a number of investigators tried to improve the efficiency and power output of Hartmann's whistle.[10, 11] Because there is a periodic swelling of the air stream so that the widest part of the stream, δ, is equal to $1.3A$, Boucher[12] suggested that the resonator aperture should be larger than the nozzle aperture by a ratio $B/A \geqq 1.3$. The maximum width of the stream can thus be accommodated within the resonator without frictional losses from contact with the resonator walls. Peripheral layers are, of course, carried along with the jet to an appreciable extent. Increasing B/A to 1.3 or above leads to a substantial increase in acoustic power, practically doubling the efficiency of Hartmann's generators.

The polar energy distribution curve of a standard Hartmann whistle shows the bulk of the energy concentrated near a plane normal to the axis, halfway between nozzle and resonator. Making use of this observation, Boucher suggested that the resonator nozzle should be set inside a secondary resonance chamber of special shape.

Altogether, these different improvements increased the efficiency of air-jet whistles into the 10 to 20% range.

Industrial processing very often requires many kilowatts of acoustic energy, and this led various authors[13-16] to combine numerous whistles into a single generator. We then have a multiwhistle arrangement that can vary in shape and power.

This type of generator has the additional great advantage of being able to deliver an appreciable amount of power without being dependent on the emissions frequency. This is not the case for a Hartmann whistle, whose frequency and power vary inversely. For instance, Hartmann and F. Lazarus[17] indicated that one of their whistles, which produced 160 w. at 10 kc., only gave 6 w. at 50 kc.

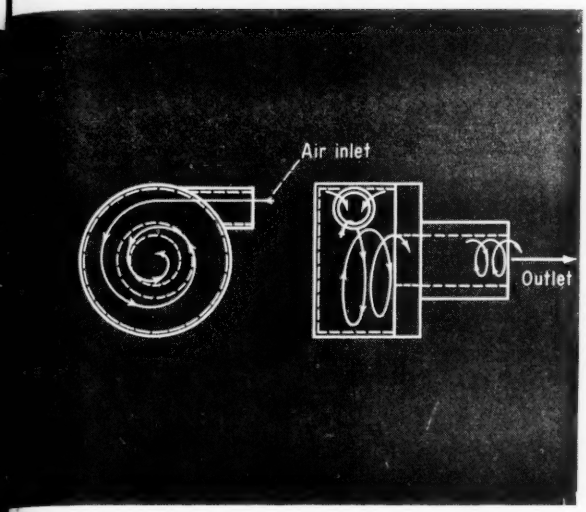
A static whistle developed by Levavasseur[18] is also derived from the Hartmann whistle family. From the geometrical point of view, it is generated by the rotation of an ordinary whistle around a horizontal axis; this is why this generator is sometimes called a "generalized whistle." If instead of generalizing an ordinary whistle, a Hartmann type is generalized, an ultrasonic emission is obtained.

In the industrial form, the supersonic air-jet nozzle of Hartmann is replaced by a very fine annular slit, while the cylindrical cavity of the oscillator is replaced by a cavity of toroidal shape.

Unfortunately, this type of toroidal whistle is subject to numerous irregularities when functioning in industrial applications. For instance, the breaking of the layer of air at the edge of the cavity is not always even, and acoustic "short circuits" are often produced. While recent models promise improvement in this respect, the necessary modifications take up considerable space and involve mechanical complications.

Varying the frequency requires changing the size of the toroidal cavity, which is not always practicable in the field. A combination of whistles is more flexible, since the frequency can be modified in operation either by pressure variation (within certain limits), or by changing the distance between nozzles and resonators.

The third fundamental type of whistle is generally known as the stem jet. As shown in Fig. 2c, this device consists of a cylindrical rod or stem in the axis of a nozzle resonator system. This arrange-



Whistles represented here are, from left to right, the Galton, Hartmann, stem jet and vortex.—(Fig. 2)

ment makes it possible to keep certain levels of intensity constant, while decreasing the compressed gas consumption by about 50%.

The most remarkable feature of this design is that it allows the production of high frequency sounds at a very low pressure (5 to 35 psi.) upstream from the nozzle mouth. For instance, a stem jet designed by S. Asklof and M. le Landais[19] recently reached an intensity level of 160 decibels at 25 cm. from the sound source, with nozzle pressure as low as 30 psi.

The stem jet is the only type of whistle that produces powerful sonic emissions at pressures below the critical excess pressure (0.9 kg./cm.^{2}) at which the radiation from a Hartmann air-jet whistle ceases. While in the Hartmann type, the total acoustic radiation is proportional to $\sqrt{P - 0.9}$; in the stem jet, it is proportional to $P - 0.3$. A Schlieren study of the shock wave pattern of the stem jet arrangement[20, 21] showed an air-jet structure entirely different from the classical one observed with Hartmann whistles.

All these factors point up the far-reaching changes that the stem introduces. While more fundamental research is called for, this device seems to have a tremendous potential even in the present state of the art. The powerful emissions achieved between 9 and 15 kc. with low air consumption will certainly lead to numerous future applications in ultrasonic processing.

The fourth fundamental type of whistle is the "vortex." As shown in Fig. 2d, this whistle basically consists of a circular tube into which air is introduced tangentially, creating a vortex by rapid rotation. If this rotating air stream is allowed to escape through an opening, a powerful emission is produced at a frequency that is a function of the applied gas pressure.

During the passage from the larger diameter to the smaller, the rotational velocity of the gas stream increases according to the law of conservation of angular momentum. The sound is produced when the high-speed air jet escapes from the small opening. It can then be applied directly, or reinforced by means of a resonance chamber.

Vonnegut[22] made a thorough study of the emission mechanism in air vortex whistles, and concluded that the air rotates at the frequency of the sound produced by the whistle. He gave the following formula, which provides a rough approximation for the emission frequency.

$$F = \alpha[V_s/\pi D][(P_1 - P_2)/P_2]^{1/2}$$

where F is the frequency, V_s the velocity of the sound, D is the diameter of the tube, P_1 is the entering pressure, and P_2 is the exhaust pressure. α is a constant of value less than one, which makes allowance for the decrease in rotational velocity due to the friction losses against the cylinder walls. The actual frequencies of Vonnegut's whistle were about 15 kc.

Unfortunately, little attention has been paid so far to acoustic power and efficiency measurements for this type of whistle. If these measurements come up to expectations, the whistle could find many applications. Easily constructed, without need for precise adjustments, it could develop into a reliable, powerful sound-source for industrial processing.

The liquid whistle "Hydrokenon" developed by Greguss in Hungary[23, 24] for liquid-phase processing is based upon the same principle. Here, the air jet is replaced by a jet of liquid under pressure, and an appreciable amount of acoustic energy is thus produced.

Also of interest is the same author's "ultrasonic burner," which uses the sonic energy of a vortex whistle to increase the combustion rate of an oil burner.[25]

Dynamic Generators (Rotary Sirens)

In this second category of generators, we find two fundamental types of designs.

The first one will be designated as the Allen-Rudnick[26] type because these authors have been the first to popularize the ultrasonic siren for industrial processing in this country. The second type was designed by the Polish scientist, B. Masczewski-Rowinski.[27]

Fig. 3 shows two of the many mechanical designs derived from the Allen-Rudnick generator. The most important features are the driving motor (speed between 8,000 and 50,000 rpm.); the rotor with

perforated holes (generally between 50 and 300); the stator with numerous openings, which face those of the rotor and are a very short distance away from them (between 0.0005 and 0.005 in.); and the casing or storing chamber that delivers the compressed air or gas.

Turbine specialists conceived of various designs for the positioning of ball bearings, the prevention of excessive loads on these bearings, and the equalization of the large stresses produced by the high rotational speeds. This type of generator represents quite a challenge for mechanical designers.

Rotative sirens radiate the sound from the stator ports, either laterally or vertically according to the shape of the rotor. In the first case, a reflector, usually parabolic, is used to rectify the sound beam.

The power radiated by sirens decreases rather sharply in the higher frequency ranges. As for efficiency, some pretty fantastic figures have appeared in commercial leaflets or even in technical papers. Some of these should not be taken at face value—it is important to form a personal, critical opinion as to the kind of measurements made by an author or a manufacturer.

There are three main techniques for rational determination of the radiated acoustic power. The first[28] derives from thermodynamics; the second is purely acoustic and based on the study of the radiation patterns,[9] and the third is based on radiation pressure measurements.[29] In practice, the efficiency of rotary sirens can range from 20 to 50%, but it is usually closer to the first figure, except for some small sirens used for environmental testing.[30]

Important in rotary siren design is the spacing between stator and rotor. The closer the distance between them, the higher the output.[31] However, there is a practical limit to how small we can make this distance, since a deposit of fine particles can cause clogging.

Shape of the ports also has to be considered carefully. Milne and Fowler[32] in England, and later Inoue[33] in Japan, have investigated this problem. The latter, for instance, studied five types of openings, came to the conclusion that if a comparatively pure tone is required, the stator ports should be circular, the rotor ports rectangular.

Table I shows some characteristic performance data for Allen-Rudnick-type sirens.[34]

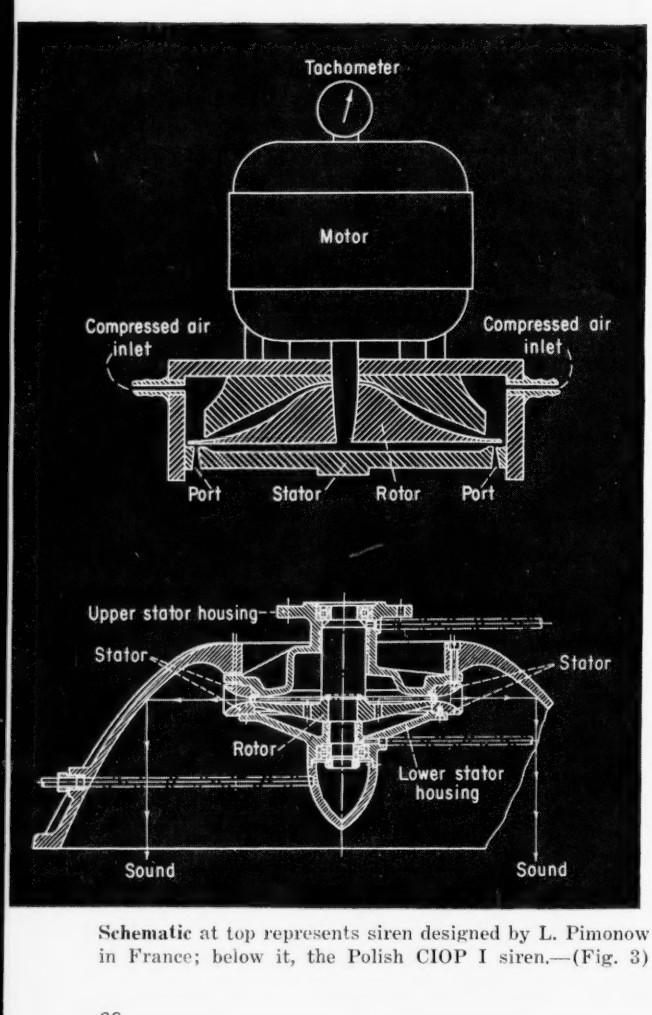
Despite the initial enthusiasm invoked by the appearance of the first industrial rotary sirens, it must be admitted that due to power and frequency limitations the Allen-Rudnick types have not entirely lived up to expectations. As we shall see later, it is often very important to emit complex and easily variable frequency spectra. Rotary sirens are poorly adapted to this kind of performance—they cannot furnish varied frequencies while operating, except by adding expensive and cumbersome speed variation apparatus.

Finally, perhaps the greatest problem is the high cost of maintenance. In atmospheres of corrosive and dusty gases, it is not easy to keep a rotor turning continuously at speeds of 20,000 rpm. and higher for extended periods. Furthermore, the rotors frequently get out of balance because of deposits or corrosion; the bearings then overheat, which can cause serious stoppages.

If sirens are going to overcome their handicap relative to whistles, what is needed is a rugged and reliable piece of equipment with good flexibility in the production of various frequencies.

Masczewski-Rowinski[27] does not seem too far from such a product. He recently designed a new type of rotary siren called CIOP II, which is shown in Fig. 4. This generator represents an entirely new conception and appears very attractive from the industrial point of view. The acoustic emission is radial and directed from the periphery towards the axis of the generator. A central reflector rectifies the acoustic beams.

The siren is directly coupled to a centrifugal extraction fan that removes the agglomerates immediately after they leave the high-intensity zone. In-



Schematic at top represents siren designed by L. Pimonow in France; below it, the Polish CIOP I siren.—(Fig. 3)

Characteristics of some typical rotary sirens—Table I

Type of Siren	Radiated Power, W.	Frequency, Kc.	Air Consumption Std. Cu. M./Hr.	Pressure at the Casing, Kg./Cm.^{2}	Power Consumption Kw.-Hr.
U_4, Ultrasonic Corp. (USA)	200	22	255	0.35	1.2
CIOP—I (Poland)	200	17	620	0.70	1.0
CIOP—II (Poland)	500	8.2	620	0.70	1.0
KRW (Poland)	300	8.2	480	0.5	3.0

Polish CIOP II siren promises improvements in acoustic intensity, efficiency and flexibility. — (Fig. 4, top)

Electropneumatic transducer electrically modulates powerful air flow to produce sound of many frequencies.— (Fig. 5, bottom)

tensity levels as high as 170 db. are achieved in the concentrated field zone. The power of the entrainment motor (2 kw.) and the compressed air consumption (110 cu.m./hr. free air) appear very reasonable. Interchangeable rotor disks having 63 and 250 holes give this generator great functional flexibility at high and low frequencies.

Before concluding this review of high-power generators, we should say a few words about sound sources that do not fall easily into the two above-mentioned categories. These are the modulated airflow loudspeakers and the membrane horns. Both may find future applications in the aerosol processing field.

For instance, the Electropneumatic Transducer[35] (Altec-Lansing type 6786) is a device for generating acoustic energy by electrically modulating a powerful air flow (150 cu.ft./min. free air at 25 psi.). Fig. 5 illustrates a simplified cross-section. The air valve consists of a voice coil. A slotted ring, 0.06 in. wide, provides the air passage. The stationary slot is located adjacent to the moving slot; with no modulation, the effective opening is 0.030 in.

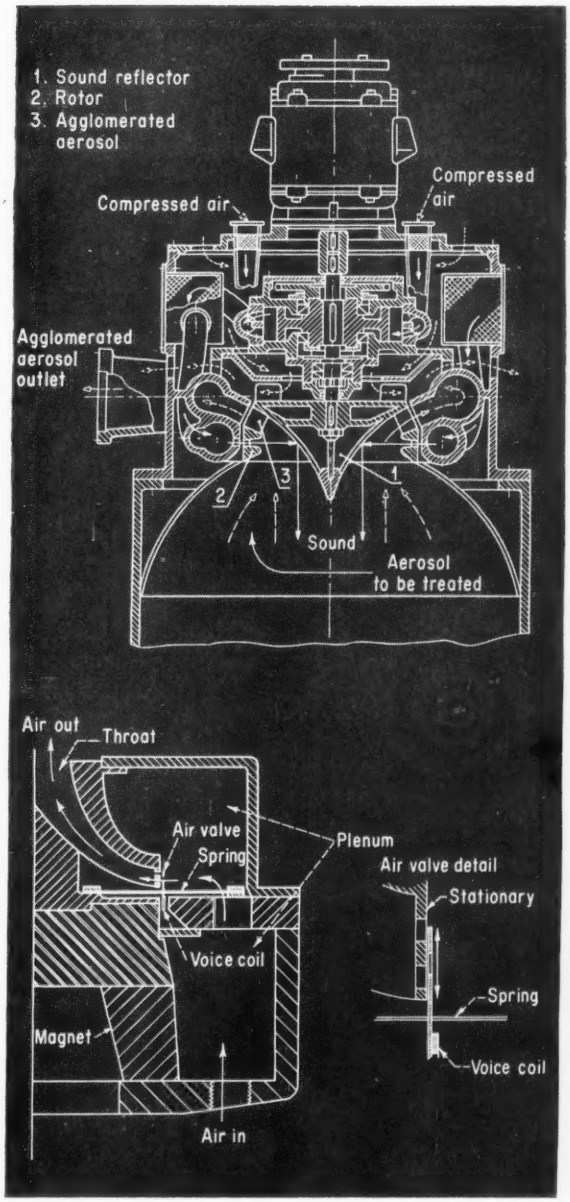
The generated power at 0.5 kc is approximately 2,500 w., and at 1 kc. is 1,000 w. The useful frequency range for this generator lies between 300 cycles/sec. and 3 kc./sec. The driving power for full modulation is 100 w. In contrast to the rotary siren, the modulated air horn is not a single-frequency device.

What is sometimes called a "diaphragm siren" consists of a generator with a metallic diaphragm that is made to vibrate in the same manner as that of a telephone. R. E. Rasmussen and T. Rallis recently used such a generator for fog processing in the acoustic laboratory of the Danish Academy of Sciences. The emission frequency was 300 cycles/sec., the output 300 w., and the efficiency 16%.

With certain precautions, this type of siren may also be used advantageously for mist agglomeration in a mist precipitator.

Influencing Factors

When designing a sonic precipitator, or when using acoustics to augment conventional precipitators, one has to consider the various factors involved in the



acoustic coagulation process. Let's make a rapid survey of these variables.

Frequency. Of the eight main types of mechanisms that make up the sonic agglomeration process, the intensity of five of them increases with an increase in emitted frequency. This may partially explain the old tendency to use vibrations in the ultrasonic range (above 16 kc.) However, as it is more difficult to produce powerful emissions in the high frequency range than in the low, most of the industrial installations described in the literature operate below 5 kc.

Until recently, particular emphasis was placed on the ortho-coagulation mechanism,[36] whereby the relative motion between a suspended particle and the gas molecules is considered most effective if the amplitude ratio X_p/X_g equals 0.5. (X_p represents the vibration of the particle, X_g that of the gas.) Fine corpuscles should thus be processed at high frequency and greater ones at a lower frequency.

As most industrial aerosols contain particles of widely different size, not only the fundamental frequency but also the other bands existing in the frequency spectrum play an important part in the coagulation process.

Let's consider this example. Take an aerosol consisting mainly of two sizes of particles—7 and 0.2 microns. If we process the suspension with a 33-kc. emission, the X_p/X_g ratio of the 0.2 micron particles is close to unity, whereas the X_p/X_g ratio of the 7 micron corpuscles is very low. In other words, the 0.2-micron particles will vibrate in unison with the gas, whereas the large droplets will not be influenced at all. While a 33-kc. emission would have no effect if applied separately to a homogeneous collection of each type of particle, it will have a well-marked effect on the mixture of the two sizes, as considerable flocculation will be produced by the collisions between the fast-oscillating microparticles and the motionless larger particles.

Since industrial aerosols often cover a wide granulometric range, it is obviosly good practice to set a maximum of different particle sizes in vibration. This can be done with a complex acoustic spectra, where each frequency band corresponds to a certain amount of energy that gives the maximum of coagulating power to a certain particle size.

Furthermore, as flocculation is not always instantaneous, it is useful to increase the vibration of the corpuscles after they have increased their size during the initial period. For all these reasons (which were underlined as early as 1948 by White[37]), it is of the greatest importance for sound generators to have a large and variable frequency range.

Sound Intensity. This is the most important single factor, because all the coagulation mechanisms represent increasing functions of the acoustic intensity.

Some sirens are coupled with focusing horns, which means that the intensity measured at a certain distance from the generator does not give a correct idea of the output. The only safe way to evaluate the capabilities of the siren is to study its radiation pattern. However, in the simplified case of an emission within a resonance chamber, the intensity measured in decibels can be used to compare power outputs. The literature suggests 130 db. (10^{-3}w./cm.^{2}) as a lower limit for practical utilization, with 150 db. (10^{-1}w./cm.^{2}) as a desirable value.

To avoid confusion, it is often better to speak of "acoustic power"—defined as the total number of acoustic watts radiated by the sound source. (Regarding the magnitude of this acoustic power, an orchestra of 75 musicians playing "fortissimo" produces a maximum of 70 acoustic watts, while today a medium-size industrial siren delivers at least 1 kw. of sound.)

White indicated that the acoustic power requirements should be 1 watt for 1 to 5 cu.ft./min. of gas treated. In practice it is seldom possible to achieve a high recovery yield when processing more than 2 cu.ft./min. of gas per radiated watt.

Exposure Time. An increase in exposure time within the sonic field means more collisions between the aerosol particles. The importance of this effect can be seen below, where m/m_o represents the ratio of the mass of the mean final particle to the mass of the initial particle.[38]

Contact Time:	Index of Agglomeration (m/m_o):
1 sec.	4
2	13
10	110

While the chance of collision between particles thus increases with exposure time, there is a practical limit to the latter. An exposure time of 4 sec. seems necessary on an industrial scale. This value can be reduced to 2 sec. when operating with a very intense acoustic field (165 db. and up).

Aerosol Concentration. In order to assure enough "efficient" collisions (non-elastic collisions followed by particle coagulation), the number of particles per unit volume of treated aerosol must be above some minimum. This is especially important if one wants to intensify the impingements due to the Bernoulli forces. Industrial experience shows the minimum concentration to be 0.5 to 1 grain/cu. ft. when particle size is from 1 to 10 microns. A concentration of 2 grains/cu. ft. seems to be one of the most favorable. In the submicronic zone (condensation fumes, for instance), the critical threshold might be slightly lowered. The addition of an auxiliary liquid mist (water, oil, etc.) is often recommended to bring the particle content up to the required concentration threshold.

For example, carbon black agglomeration was raised from 10% to 17% by introducing a very small amount of water mist.[46] More recently, in France, the Societe d'Applications Supersoniques [39] increased the collection efficiency of electrometallurgical micronic fumes by 6% by atomizing as little as 2 liters of water per hour in a 500 cu. m./hr. gas stream.

Temperature. Contrary to what happens in most other gas purification techniques, a temperature increase does not seem to raise especially difficult problems. Both Brownian-motion intensity and gas vis-

cosity increase with temperature, and they both favor particle agglomeration. (The whole effect of a temperature increase is rather complex since we also have to consider the variations it causes in the speed of sound and in the specific mass of the gaseous medium.) As a generally accepted rule, 1,500 F. is taken as the upper limit for industrial processing. Above this temperature, numerous technical problems crop up since the generators have to be built of special alloys or ceramics, or treated with temperature-resistant coatings.

Aerosol Turbulence. The flow characteristics of the aerosol stream are of utmost importance because the turbulence level inside the acoustic chamber has a significant effect on the coagulation yield. Matula[40] demonstrated that the turbulent flow induced by the acoustic field itself greatly enhanced the coagulation mechanism. More recently, it was shown that two acoustic fields of the same intensity but corresponding to different turbulence patterns could cause different degrees of smoke agglomeration.[41] This could explain why the yield of industrial precipitators changes when the method of introducing the aerosol into the agglomeration tower is modified.

How These Factors Affect Design

The points we have discussed are not the only ones that govern the operation of acoustic precipitators. For instance, H. W. Saint Clair[39] attaches great importance to nonlinear distortion phenomena. He has pointed out that pure sinusoidal vibrations are rare in a high-intensity field. Harmonics are numerous, and consequently there are more-or-less complex series of vibrations inside a resonance tower.

As the reader can see, the phenomena involved in acoustic precipitation are quite complex. Each industrial problem has to be considered as a special case. The design of an acoustic fume agglomerator largely reflects a compromise between acoustic, aerodynamic, structural and economic requirements.

The design problem is a team job that has to be handled carefully by a group of physicists and engineers, and even if the conclusions of these specialists are optimistic, it is essential to go through a preliminary pilot-plant phase before erecting an industrial unit.

Those who prefer a more Cartesian approach to this problem should read Inoue's paper entitled "Study of a Sonic Dust Agglomerator".[33] This author has developed a set of theoretical formulae that, despite numerous simplification hypotheses, agree satisfactorily with experimental observations. These formulae were established for rotary sirens operating countercurrently (acoustic emission in the direction opposite to the gas flow), but they have also been verified for parallel-flow installations with static sirens.

If we designate by η_A the acoustic efficiency of the generator, Inoue gives the following expression:

$$0.07 < \beta\eta_A < 0.16$$

where β represents a constant that is characteristic of the plant. From our own experience, $\beta\eta_A$ seems closer to 0.07 than to 0.16.

After we calculate the constant β from this expression, its value can be substituted in the following equation:

$$I = \frac{4\beta I_0}{\pi D^2}$$

where I (w./cm.^{2}) represents the average intensity (resonance conditions) inside the agglomeration tower. I_0 is the acoustic power delivered by the sound generator (in w.) and D the diameter of the cylindrical precipitation tower (in cm.).

Knowing I, it is easy to calculate the coalescence constant, C, from

$$C = \sqrt{I}$$

and the agglutination index:

$$I_A = \frac{d}{d_0} = e^{Ct/3}$$

where d_0 is the mean diameter of the aerosol particles before acoustic treatment, d the diameter after agglomeration, and t the contact time (in sec.) inside the acoustic tower.

Finally, Inoue has given the following formula to compute the ideal height L (in cm.) of the acoustic tower:

$$L = \frac{3v \log_e (d/d_0)}{C}$$

where v is the mean linear velocity of the aerosol (cm./sec.) in the tower. A generally accepted value for v is 100 cm./sec.

Industrial Installations

Numerous acoustic dust precipitation plants using rotary sirens were built in the U. S. during the ultrasonic craze, and several papers describing these installations have been published.[42-47] As none of these plants are still in operation, we will confine our discussion to more-reliable and economical installations that have been built abroad in recent years. As mentioned earlier, many of these plants could stand further improvement in terms of energy consumption, but information obtained from them is of considerable interest nevertheless.

In Italy, a sonic precipitator with a static siren of 6-kc. frequency has been very successful in the recovery of stibium oxide particles escaping from metallurgical furnaces.[16]

In Germany, R. Jahn claims a precipitation yield higher than 90% for microparticles escaping from metallurgical ovens in the manufacture of ferro-alloys. Temperatures were 120 to 590 F. The whistle frequency ranged between 1.5 and 3 kc. and the average intensity level inside the agglomeration chamber reached 152 db.

In Hungary, Greguss and Tarnoczy[48] successfully used an air-jet whistle to treat flue gases from a cement kiln. The whistle was installed inside a large

chimney that discharged cement dust into the atmosphere and was directed downward at a 25° angle to the chimney walls. The radiated acoustic power was 150 w., and an intensity level of 151 db. was reached inside the resonant enclosure. The frequency ranged between 4.6 and 5.5 kc. This whistle brought about a two to seven-fold increase in the weight of dust collected daily.

In France, a sonic precipitator designed by Palme[49] recovered 90% of an aerosol containing dust and tar mist. This unit treated 600 cfm. of hot gases escaping from an electrolysis cell in an aluminum plant.

The ultrasonic pilot plant that was shown schematically in Fig. 1a, was designed by Boucher[20] in France, for the precipitation of electric furnace fumes. The precyclone, which had a tangential inlet, removed the largest particles. It was followed by a cylindrical chamber in which standing waves were produced. After sonic agglomeration, the flocs settled to the bottom of the tower by inertia and were collected in a hopper, while the smaller agglomerates were collected by centrifugation in a standard multicyclone.

The pilot-plant was operated under a slight negative pressure produced by an exhauster. The gas to be cleaned came from the open hood of a calcium carbide furnace and was fed into the acoustic precipitator at a temperature of 250 F. Most of the particles suspended in the gas were between 1 and 5 microns in dia.; a few ranged between 15 and 30 microns.

Table 2 shows some of the most significant results obtained with this pilot plant. Tests 1 and 2 show that efficiency increases 10% when the proper acoustic field is produced. Tests 3 and 4 point out the significant effect of adding small quantities of water mist (1 cc. per 7 cu. ft. of gas). As previously discussed, the influence of such an auxiliary mist is greater when dealing with low-concentration aerosols. Tests No. 5 and 6 stress the importance of correct positioning of the resonance plate.

After numerous tests, the author concluded that ultrasonics can lead to increases of 58% to 86% in over-all collection efficiency during a complete melting cycle, and that even low-concentration aerosols (0.25 to 0.5 grain/cu. ft.) could be treated. The energy consumption for these would be about 6 kw. per 1,000 cfm.

In 1958, the French Societe d'Applications Supersoniques used the same pilot plant to precipitate cement dust at the exist of a rotary kiln. The volume of gases treated ranged between 400 and 600 cfm. Over-all efficiency reached 99% when heavy dust loadings (10 grains/cf.) were being treated.

Using the experience gained at pilot-plant scale, Slavik and Taraba[50] designed several large-scale precipitators in Czechoslovakia. One of these cleans the exhaust gases of a power station, another successfully handles 10,000 cu. m./hr. of lead oxide fumes at a temperature of 120 C. The over-all efficiency of the latter averaged 95-98% over a two-year period. The mean diameter of the collected particles ranged between 20 and 30 microns. The plant uses a rotary siren of 15-kc. frequency, whose energy consumption corresponds to 1.6 kw. per 1,000 cu. m./hr. of gas treated.

Also in Czechoslovakia, Geid and Slavik[51] have used the artificial turbulence created by high frequency sounds of large amplitude to accelerate gas dissolution in a dispersed liquid phase. They treated power station flue gases that had high SO_2 content. This involved experiments in which four rows of Hartmann whistles with frequencies of 8 to 11 kc. operated above small vessels containing ammonia (see Fig. 7). The SO_2 reacted fairly rapidly to form solid ammonium sulfate, so that after several minutes the SO_2 content of the tail gas was sharply decreased. The Czech investigators intend to apply this acoustic technique to larger sirens, and to treat sulfurous gases of power stations burning low-calory soft coal.

Polish engineers have been very active during the past five years in the design and construction of high-power sirens. Therefore, they have gained a great deal

Large-scale acoustic precipitator treats nonferrous metal fumes, at Scopiniece, Poland.—(Fig. 6)

of experience in sonic dust precipitation, both at pilot-plant and industrial levels.

A group of engineers[52] used a rotary siren called KRW to coagulate 6,000 cfm. of fumes from a metallurgical melting furnace (Fig. 6). The KRW siren was said to have 20% efficiency when operated below 2 kc. with a pressure of 1.5 kg./cm.^{2} Air consumption was 561 cu.m./hr. at 1.5 kc., with 3,160 acoustic watts being radiated. The dust load ranged from 0.7 to 18 grains/cu.m. The maximum intensity level inside the resonance tower reached 4 w./cm.^{2}, but in normal operation averaged 0.2 w./cm.^{2} According to the radiated power, over-all efficiency varied from 90% to 99% in weight.

The plant consisted of a 30-ft. tower operating on the countercurrent principle, followed by a single cyclonic collector to separate out the agglomerated particles.

Another series of tests was undertaken in the same installation by Masczewski-Rowinski[53] and associates with a different rotary siren of the CIOP-I type. While collection efficiency was good, power consumption was high.

Today the Poles are experimenting with the new siren CIOP-II in a large transportable modern pilot-plant of 1,000 cu.m./hr. capacity. As discussed earlier, this siren represents a very bright hope from the point of energy consumption and trouble-free operation, and so far some highly encouraging results have been obtained in processing a suspension of phthalic anhydride droplets. Efficiency has been 98-99%.

While few details are known about the industrial precipitation plants erected in the Soviet Union, Russian scientists have paid a great deal of attention to the subject of acoustic precipitation, as can be seen in Tsetlin's brochure entitled "Acoustic Coagulation of the Aerosols and its Engineering Application," and many papers of other authors.[41, 54-58]

In Japan, two industrial plants installed in 1952 for tar removal in the gas industry, have been in use for eight years, and are quite efficient.[59] Each ultrasonic precipitator handles 6,000 cu.m./hr. in a vertical countercurrent tower 33 ft. high with a 3½-ft. dia. Contact time inside the agglomeration tower is 6 sec. The final collector is a drum-type impinger. Tar mist loading has usually ranged between 6 and 15 g./cu.m., with a particle size range of 1 to 10 microns. The sound source is a rotary siren with a 35% over-all efficiency. An oil-washing device eliminates tar deposits inside the bearings and between the rotor and stator.

Collection efficiency with sound apparently averages 30% better than the best that can be obtained without it. In continuous operation, over-all electric energy consumption ranges between 3.5 and 4 kw. per 1,000 cfm. of aerosol treated, which is more reasonable than many plants, but still not ideal.

It can't be denied that high energy consumption frequently poses a serious practical problem, especially where power costs are high. As generally agreed, the investment cost of an ultrasonic installation is lower than that of an electrostatic precipitator treating the same volume of gas. However, the operating expenses of the latter are remarkably low—0.2 to 0.6 kw. per 1,000 cfm. Hence to be fully competitive, rather than reserved for special cases, the acoustic technique requires very reasonable running expenses.

The plants we have discussed have not as yet entirely fulfilled such a condition. In the most favorable examples (lead oxide fumes and tar mist), over-all energy

Hartmann whistles speed up SO_2 dissolution in power-station flue gases.—(Fig. 7)

Electric-furnace fume precipitation—Table II

Test No.	Inlet Concentration, Grains Cu. Ft.	Gas Flow Rate, CFM.	Type of Acoustic Emission	Type of Cleaning	Efficiency (In Weight), %
1	0.44	230	Without ultrasonics	Dry	84
2	0.44	188	7.5 + 10 + 26 Kc.	Dry	94
3	0.35	241	10.5 Kc.	Wet	86
4	0.66	265	10.5 Kc.	Dry	26
5	0.39	176	(7.5 + 10 + 26 Kc., but no resonance)	Dry	42
6	0.39	176	(7.5 + 10 + 26 Kc., with resonance)	Dry	92

consumption of the system corresponded to an expense of 1.6 to 4 kw. per 1,000 cfm. of gas treated, but in many other cases it averaged 6 to 8 kw. per 1,000 cfm., which is too high even when the lower investment cost is considered.

There is another quick way to evaluate economic appeal of an installation. Let us call Ω a coefficient that we define as the ratio of the volume of gas treated to the volume of gas consumed by the siren. Table III shows that the values of Ω oscillate between 1.8 and 5 for some of the installations previously described. This is unsatisfactory if there are other ways of doing the job; Ω must be at least 10 to be competitive industrially. Only the tests undertaken in Japan, and the last results from Poland with the siren CIOP II, let us hope that this ratio will be surpassed.

Of course in high temperature applications, particularly if the product is very valuable, or has to be recovered dried, it may make good sense to operate a precipitator where Ω is less than 10. The same holds true if air pollution is a critical factor, if tests show that ultrasonics can do the best job. However, these cases are not the general rule, and the reader must not again be prematurely overenthusiastic about the economics of precipitation plants for all applications.

We shall see in the next section that other approaches based on entirely new concepts might play the biggest part in the future development of acoustic gas-cleaning.

Ultrasonics as a Supplement

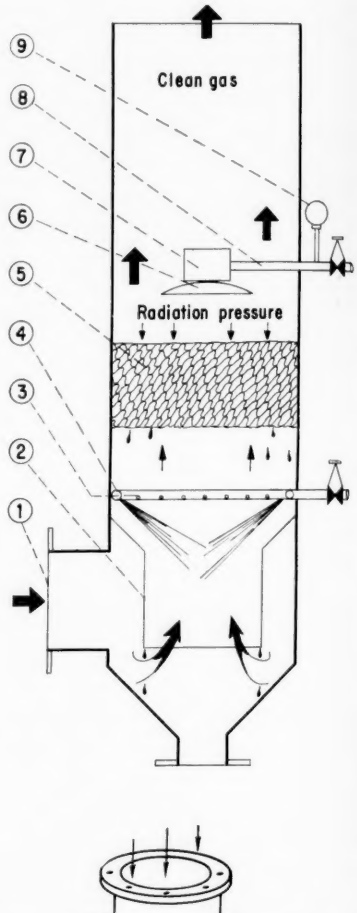
As ultrasonics is a relatively expensive form of energy, why should it do the job by itself and at a high cost when a much smaller amount added to an existing precipitation or cleaning system can give identical or better results at a cheaper rate?

In aerosol processing, one remarkable example of the latter approach is the S. Asklof process[60] that we shall now discuss.

Gas consumption of some typical sirens—Table III

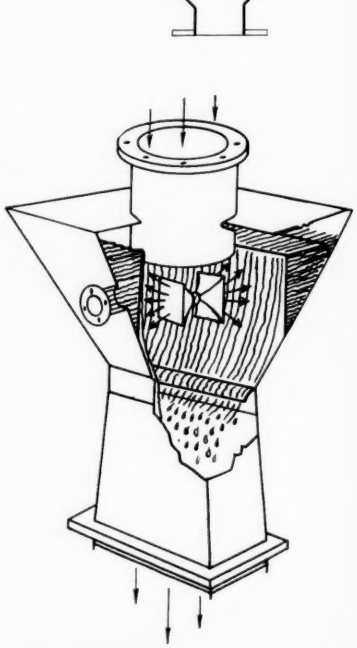
Type of Siren	Q_s Siren Gas Consumption Std. Cu. M./Hr.	Q_g Aerosol-Stream Flow Rate Std. Cu. M./Hr.	Ω Q_g/Q_s
KRW (Poland)	1,000	2,500	2.5
CIOP. I (Poland)	1,160	2,060	1.8
CIOP. II (Poland)	110	1,200	10.9
Levavasseur. I (France)	150	500	3
Multiwhistle RB (France)	100	500	5
Y. Sawahata (Japan)	600	6,000	10

It has long been observed that when an intense sound is emitted above a metal screen mesh, the screen acts as an acoustic grating, spreading and diffracting the waves over a large area. By adjusting the ratio λ/D (the wavelength of the sound divided by the mean diameter of the mesh holes) it is possible to reinforce

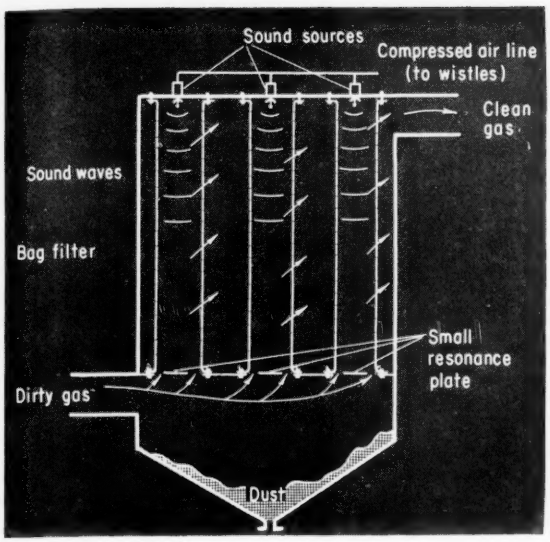


Acoustic demisters, such as this one designed by S. Asklof in Sweden, can achieve economical, high-efficiency precipitation of liquid aerosols.—(Fig. 8)

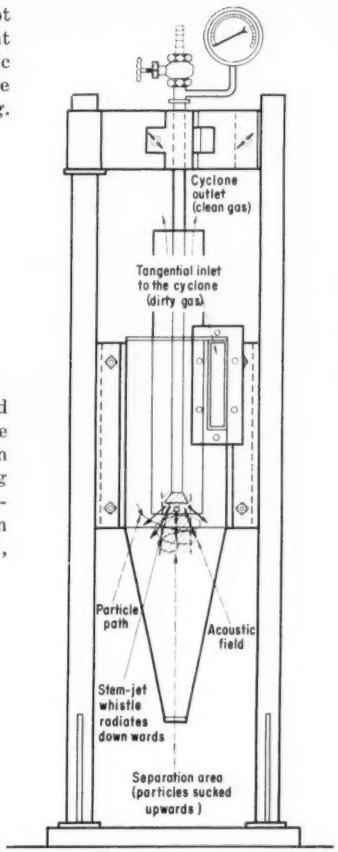
1 Aerosol-inlet duct
2 Inner cyclone duct
3 Liquid-scrubber inlet
4 Spray ring
5 Demisting mesh
6 Sound-source reflector
7 Sound source
8 Compressed-gas inlet
9 Pressure gage



Sound generator irradiates against the curtain of water to produce strong surface cavitation and a mist, thereby improving the collection efficiency of this S-F venturi scrubber.—(Fig. 9)



Bag filters can be kept clean by intermittent or continuous sonic emissions that dislodge dust particles. — (Fig. 10, left)


Cyclone outlet (clean gas)
Tangential inlet to the cyclone (dirty gas)
Particle path
Acoustic field
Stem-jet whistle radiates down words
Separation area (particles sucked upwards)

Sonic barrier applied to conventional cyclone can increase collection efficiency by repelling smaller particles normally re-entrained in tail gases. — (Fig. 11, right)

and concentrate the sound in some areas, or to spread the radiating sound on a wide solid angle, each aperture being considered as a point-source of sound. Interference phenomena can also be set up.

When operating with a powerful sound generator, a fair amount of sound is transmitted through the screen mesh. For instance, a supersonic air-jet whistle (output 80 w.) operating 1 ft. above a 2-in.-thick mesh can cavitate tap water 1 ft. below the mesh. The radiation pressure is considerable, and the force fields created through and underneath the mesh can serve to deflect or repel fine suspended aerosol particles.

Let us now consider the apparatus shown in Fig. 8. In this precipitator, the aerosol stream enters through a tangential inlet port, and the coarser particles are eliminated through centrifugal motion. The finer corpuscles then flow towards the mesh arrester where the oncoming sound waves deflect the suspended matter against the metal threads, thus causing a high degree of agglomeration. When dealing with a liquid aerosol, the high-intensity sound-field repels some droplets, helps impingements between others (orthokinetic agglomeration), and sweeps out the liquid film covering the metal threads of the arrester. Altogether, these mechanisms can lead to a very high efficiency.

While mesh demisters without acoustics are not efficient with droplets smaller than 10 microns, the addition of radiation pressure makes it possible for them to collect submicronic droplets. Since the function of the sound source is only to improve the capabilities of a mechanical collector, the energy consumption (sound source + exhauster) becomes very reasonable—it is said to be between 0.7 and 2 kw. per 1,000 cfm. of gas treated. Liquid aerosols containing a suspension of fine soluble microcrystals may also be handled economically by this precipitator.

Fig. 9 represents a S-F-type venturi scrubber. The liquid flows downward along the sloping walls in a continuous film, is directed across the throat of the venturi by the deflecting lips, and is then atomized by the force of the high-velocity gas. If we add an air-jet whistle or any suitable high-intensity sound source, we will create a violent surface cavitation and therefore a highly turbulent mist. This increases particle impingements. Here again, the acoustic energy involved will correspond to reasonable figures.

In a similar vein, Schmieg Industries, Inc., Detroit, Mich., is investigating the influence of an acoustic field inside one of its wet collectors of the liquid-curtain type. Relying on the great turbulence and the strong cavitation created at the gas-liquid interface, the company expects to improve the effectiveness of its gas washer both for gas dissolution and aerosol precipitation (U. S. patent pending).

Fig. 10 shows a setup for the cleaning of bag filters by means of high-amplitude acoustic waves. The first idea for this came in 1956, when H. I. Abboud described an arrangement that, while not suitable from the acoustic point of view, held interesting possibilities. He suggested radiating high-intensity sound from the clean side of the filtering media. The damping of the sound waves, while traveling through the fabric, evidently limited the efficiency.

An emission on the dusty side proved to be a most

efficient and inexpensive way of cleaning the filter, and, therefore, of improving the over-all collection efficiency.

The most economical and simple type of collector, the cyclone, can also benefit from the ultrasonic technique, and this application can obviously have great practical importance.

The classic studies of Ter Linden[62] and Brun[63] established that the gas flow inside a cyclone is three-dimensional. In other words, at any point within a cyclone, the velocity can be resolved into three components, V_t, V_r and V_h, these being respectively tangential, radial and vertical. Experimental measurements indicate that except for a core of low pressure in the center, the pressure is high throughout the entire cyclone. The core, which has an important vertical velocity component, extends the full height of the collector, and its diameter is about four-tenths that of the central exhaust duct, as shown in Fig. 11.

The efficiency of all types of cyclones is strongly governed by the shape of this central zone, which is often called the separation area. Inside this region, instead of sliding down into the receptor, the fine particles are sucked upwards and exhausted together with the cleaned gas. If we create a strong downward acoustic field in this area, the powerful radiation-pressure forces will counteract the upward motion of the finer particles. An invisible "sonic barrier" will thus be created that may repel the smaller corpuscles normally re-entrained in the tail gases.

A sonic generator (whistle or transducer) located inside the exhaust duct can easily do this job without seriously disturbing the flow stream throughout the entire cycle.*

For best results, a high sound intensity is recommended (above 150 db.).

What Can We Conclude?

Let's now draw some general conclusions from this survey on aerosol processing. We have seen that for effluent dust problems, the classic acoustic method—agglomeration in a resonant tower—is not cheap. In most cases, the running expenses will be higher than 4 kw. per 1,000 cfm. of gas treated. However, investment costs will be lower than those of the electro-precipitation technique, and it will be perfectly safe to collect any kind of particles at high temperature.

Handling heavy dust loadings (above 5 grains/cu. ft.) is not advisable without a preseparator, since this involves serious risks of clogging the sound generators.

Whistles are generally more reliable than rotative sirens, but in the latter group, the Masczewski-Rowinski generator seems to be a most promising sound source.

Treating traces (below 0.5 grain/cu. ft.) of fine materials will usually require an auxiliary spray.

For liquid aerosols or mists, the new radiation pressure method combined with a mesh arrester is quite worth investigating. Investment cost can be very low, and running costs competitive. Traces of solid particles, soluble in a solvent, can also lend themselves to this particular technique.

Finally, the reader should keep in mind that acoustic energy can be of considerable help in some particular gas-washing problems, or for improving existing types of precipitators or gas washers. Here again, running costs can be very favorable.

PART II—ACOUSTIC DEFOAMING

The formation of foam in many industrial and chemical processes has long presented a considerable problem. While the introduction of chemical antifoaming additives has certainly helped, airborne sounds and ultrasounds now provide a simpler and often more economical solution.

The use of ultrasonics as a foam inhibitor has been investigated at various times since 1944,[61-67], but it was only with the recent appearance of powerful and economic stem-jet whistles that large-scale applications for acoustic defoaming could be seriously considered.

The mechanism of ultrasonic defoaming can be attributed to the periodically collapsing force of the propagated sound waves, the unidirectional radiation pressure, the induced resonant vibrations in the bubbles, and the turbulence created by the sonic wind.

In the medium range of frequencies (i.e. above 5 kc.), the destruction of foam can take place in one of two ways, depending on the sound intensity:[68]

Below 157 db., the first layer of bubbles is shattered, then the second layer, and so on until the total pressure exerted on the top of the foam is not sufficient to overcome the resistance of the liquid film and the pressure inside the bubble. This state is reached at a certain distance from the sound source because of the quick damping of acoustic waves.

With sonic energies above 157 db., the foam disintegration process is quasi-instantaneous, as demonstrated through high-speed-camera motion studies.

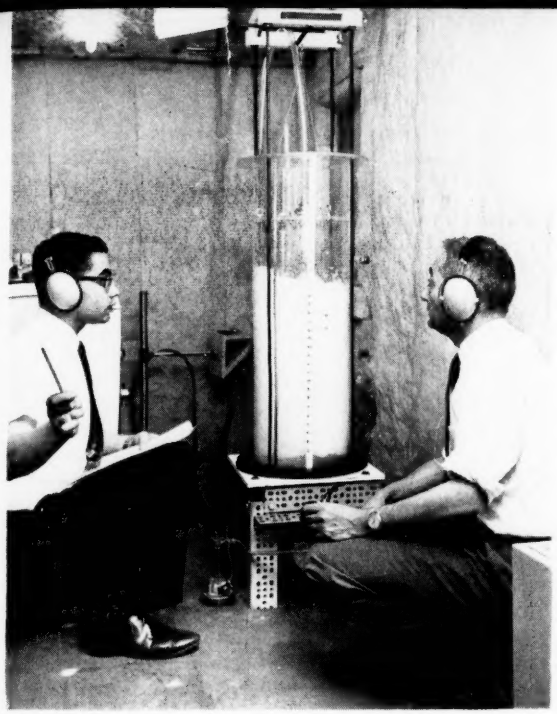
In the very low frequency range (particularly below 2 kc.), the mechanism of foam destruction is entirely different. In this case, the foam bubbles only explode when located in a pressure antinode region (negative pressure zone). To achieve complete foam control, the intensity level must be high enough to insure immediate, full destruction of the climbing foam before it leaves the negative region.

In short, at low frequencies, foam destruction mainly represents an acoustic pressure effect and hence needs resonant conditions; while at higher frequencies, the foam is destroyed through radiation pressure.

Experiments have already shown that stem-jet whistles at 12 kc. can control a foaming rate of 6 ft./min. over a 1 sq. ft. area, with air consumption as low as 12 cfm. of free air delivered at 25 psi.

Fig. 12 shows how a fast growing Artic Syntex 036 foam can be controlled by being held permanently at a 7-in. distance from a stem-jet whistle.

* For a better understanding of the "fountain" effect in a strong radiation-pressure forces field, we recommend the interesting report of J. P. Walker and C. H. Allen on this subject. (Atmospheric Physics and Sound Propagation, Penn State College, U. S. Army Contract No. W36-039-sc-32001, pp. 60-62, 1950.)



Dr. Boucher (right) and his assistant, Arnold Weiner, conducting an experiment in which a stem-jet whistle permanently controls what would otherwise be a rapidly rising foam.—(Fig. 12)

Studies recently undertaken by Branson Instruments, Stamford, Conn.,[9] lead us to believe that a newly-developed generator, consuming only 5-10 cfm. of free air delivered at 25-35 psi., will control climbing rates up to 15-25 ft./min.

PART III–ACOUSTIC DRYING

In industry, drying is generally achieved either by heat or by purely mechanical means, such as centrifugation or compression. High-intensity acoustic waves, especially airborne ultrasounds, offer an entirely new approach in this area.

It is well known that sonic and ultrasonic waves present alternating areas of pressure and expansion, subjecting the surface of the material to either negative or positive pressures. This creates a kind of surface cavitation that breaks the boundary layer and cancels the adsorption field.

In the first phase of drying, we can consider the surface of the adsorbent as being covered by multiple layers of molecules behaving as they would in liquid phase. Under acoustic excitation, large-amplitude sonic waves can destroy and accelerate the evaporation of this liquid film.

This mechanism concerns only the first drying phase; the second phase corresponds to the disappearance of the surface layers. This happens when the rate of diffusion through the material is not sufficient to feed and maintain multiple liquid layers at the interface.

Acoustic energy is generally less efficient during the second phase of the drying process. It is very difficult to transmit sonic energy through a gas-solid interface, as this constitutes a bad impedance mismatch.

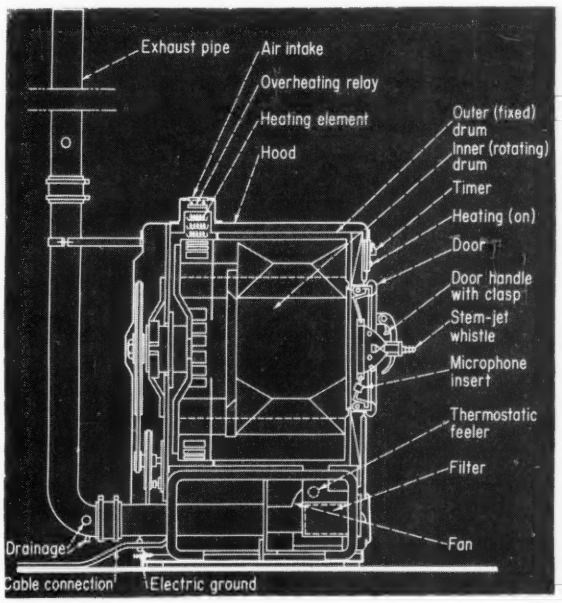
That is why the acoustic method is usually most effective when applied to the processing of granulated, porous or fibrous materials that present a high surface-area to mass ratio.

In some special cases, like the drying of granulated sugar, acoustic energy can even be very helpful during the second phase of the drying. This is due to the nucleation power of sonic waves—they accelerate the crystallization rate of the supersaturated layer that coats the sugar particles. (U. S. patent pending. American Sugar Refining Co.)

Table IV shows some of the results obtained at N. Y. U. when various materials were dried inside a 50-lb./hr. rotary ultrasonic dryer. The sound sources were of the air-jet and membrane type, and the frequencies ranged from 1.2 to 12 kc.

Fig. 13 shows a section view of the acoustic dryer used for these experiments. This apparatus, manufactured by Demister AB, Malmo, Sweden, is a small-scale rotary dryer of the tumbler type, with a variable rotational speed of 15-60 rpm. The air used to carry the moisture away is introduced at the top of the dryer. It then passes over the material, and is sucked up through a side opening leading to an exhauster.

The high-intensity sound source, which is electronically or air operated, is fixed in the front door and radiates in the axis of the tumbler. The temperature and humidity of the moist air-flow leaving the



Acoustic emission in this rotary dryer can double or triple the normal evaporation rate.—(Fig. 13)

Results of recent drying tests at N.Y.U.—Table IV

Material	Original Moisture Content, %	Moisture Removed After Processing, %	Processing Time, Min.	Temp. Inside Acoustic Dryer, °C.	Main Frequency of the Emission, Kc./Sec.	Average Intensity Level, Db.	Type of Processing
Edible gelatine	80	52.5	120	39	12	143	Sound
" "	80	18.8	120	39	—	—	No sound
Blotting paper*	65	95	12	25	12	146	Sound
" "	65	50	12	25	—	—	No sound
" "	65	80	12	25	1.2	153	Sound
" "	65	40	12	25	—	—	No sound
Yeast cake	70	30	60	37	12	148	Sound
" "	70	10	60	37	—	—	No sound
" "	70	18	60	25	12	147	Sound
Alumina gel*	90	48	90	25	1.2	154	Sound
" "	90	10	90	25	—	—	No sound
" "	90	47	90	25	12	143	Sound
Silica gel	80	79	90	45	12	146	Sound
" "	80	70	90	45	1.2	153	Sound
" "	80	51	90	45	9	142	Sound
" "	80	40	90	45	—	—	No sound
Granulated sugar	1.59	98.6	20	50	12	152	Sound
" "	1.12	98.3	20	50	9	145	Sound
" "	1.79	97.3	20	50	1.2	153	Sound
" "	0.87	91.3	20	50	—	—	No sound

* Material dried in a belt-conveyor-type arrangement.

dryer is continuously controlled by means of a thermistor and an electronic automatic hygrometer.

From the data of Table IV, one can see that the rate of evaporation can sometimes be doubled or tripled if acoustic irradiation is applied.

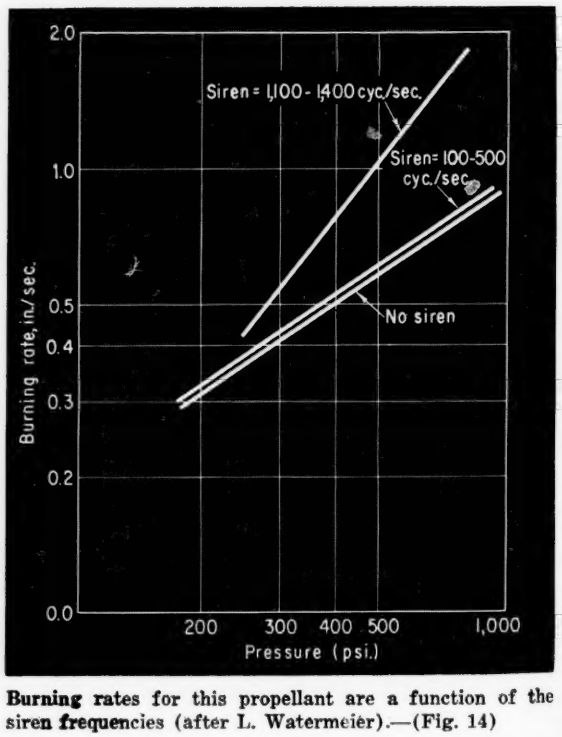
As previously stated in other papers,[70, 71] a minimum level of 143-145 db. is recommended for best results. A combination of sound and moderate heat often appears to be advantageous. The materials processed in these tests were all sensitive to variations in frequency, and within the range of our observations, 12 kc. was the most efficient frequency.

The amount of energy radiated under resonant conditions inside the dryer oscillated between 100 and 300 w. and this corresponded to a processing capacity of up to 36 lb./hr.

Work is also being done to adapt the ultrasonic technique to spray drying. Some encouraging results in developing a sonic nozzle were reported recently.[19, 70]

In summing up, we feel that high-amplitude acoustic waves can solve problems in the processing of heat-sensitive materials, particularly in the pharmaceutical, food and chemical fields. This technique can be quite competitive with vacuum-drying methods.

Freeze-drying, which is still a very expensive process, can certainly be one of the first techniques to benefit from the progress achieved by the acoustic method. The last 10% of the moisture to be removed in a freeze-drying operation sometimes requires ten hours, while 90% of the initial moisture is removed in only two or three hours. A sonic irradiation after



Burning rates for this propellant are a function of the siren frequencies (after L. Watermeier).—(Fig. 14)

the bulk of the moisture has been evaporated could very well be a means of reducing the total processing time by one-half or two-thirds.

PART IV–ROCKET PROPULSION

There is currently great interest in the application of intense airborne sounds to increase and control solid-propellant burning rates in rockets. Today there is no reliable way to achieve in-flight control of a solid propellant rocket. Only off-on control or advanced programming of the chemical propellants is available.

Both the U. S. and the U. S. S. R., are investigating systems in which a whistle or high-intensity sound generator sends high amplitude waves of suitable frequency (in general below 25 kc.) through the solid propellant core, in the same direction that the combustion gases flow. The object is to hasten the gaseous reaction rate in the thin flame layer and increase the burning rate that in turn governs the rocket thrust. Also, by varying the acoustic emission, better control can be achieved over the burning rate.

According to Summerfield,[72] the linear rate at which a propellant burns is proportional to the rate of heat feedback from the hot gaseous combustion zone to the exposed solid surface. The rate of heat feedback is, in turn, proportional to the temperature gradient in this gaseous layer: thus, the thinner the combustion zone, the faster the rate. The thickness of the combustion zone is inversely proportional to the rate of reaction in the gaseous layer, so that the faster the gaseous reaction, the faster the burning rate.

For composite propellants, the speed of the gaseous reaction is controlled by two rate processes: the chemical kinetics of oxidation and the diffusion of unmixed oxidizer and fuel gases.

With solid-fuel rockets operating at pressures above 500 psi., the controlling (slowest) process is the interdiffusional mixing. Any physical factor, such as a superimposed acoustic turbulence, that can speed up the diffusion mechanism in the gaseous combustion layer will speed up the burning rate.

For simple propellants of the ammonium perchlorate and polystyrene copolymer type, with no special additives, Summerfield established the following rate equation:

$$\frac{1}{r} = \frac{a}{p} + \frac{b}{p^{1/3}}$$

where r is the linear burning rate, p is the pressure, a is the chemical kinetic reaction time parameter, and b is the diffusional mixing time parameter.

Acoustic stirring will therefore affect the burning rate by decreasing b. If b could be made small enough to be neglected altogether, a fivefold increase in a typical propellant's burning rate would be possible.[73]

At N. Y. U., Hudson, Boucher and Richman[74] recently generalized Summerfield's results. By using an idealized mathematical model of the interaction between a flame and an acoustic system, these authors obtained the following equation:

$$\frac{1}{r} = \rho_s \sqrt{\frac{Q}{(K\,\Delta T)(D\rho_g L)}}$$

where r is the linear burning rate and D the diffusion parameter. Here again, r is a function of the intensity of the diffusion, and therefore of the acoustic field characteristics. (In the above equation, ρ_s represents the density of the solid propellant at the surface, ρ_g the density of the gas, D is the heat diffusion parameter, K the heat conductivity and L the sublimation energy per unit mass. Q is the heat generated in cal./sec.).

Watermeier's[75] remarkable work in this field should also be mentioned. He observed a marked increase in the burning rate of a double-base propellant slab when subjected to siren pulses normal to the burning surface. This increase was greatest when the propellant's burning surface was located at a velocity antinode (point of maximum pressure) and when the siren frequencies were at or near the resonant frequency of the chamber, as shown in Fig. 14.

A Concluding Thought

The coming decade will undoubtedly bring numerous improvements and innovations in the field of high-amplitude acoustic waves. We have reached the threshold of a new era when airborne sounds will be considered as a valuable tool for processes as diverse as drug drying, mist precipitation, defoaming of liquids, and rocket-thrust modulation.

While this is not to say that everything will be smooth sailing, the potential is very great.

In this report, we have tried to point out the limitations as well as the benefits of acoustic technique so that the reader will have material on which to base an objective opinion. Where possible, we have tried to call attention to applications that currently present the fewest problems, so that the process engineer can channel his interest and energies into the most promising avenues.

ACKNOWLEDGMENTS

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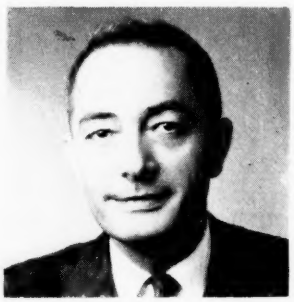
Meet the Author



R. M. G. BOUCHER *is the inventor or co-inventor of some 15 patented devices in the acoustics and aerosol fields. He is head of the ultrasonics laboratory at the Research Div. of New York University, University Heights, New York, N. Y.*

A chemical engineer with a Ph.D. in physics from the Sorbonne, Dr. Boucher came to this country in 1957.

In the last two years, he has been an official guest of such far-flung scientific organizations as the Polish Academy of Sciences, the University of Prague, and the Assn. of Mechanical Engineers, in Budapest.

He has just returned from a trip to Japan, where he acted as consultant on problems related to applied ultrasonics.

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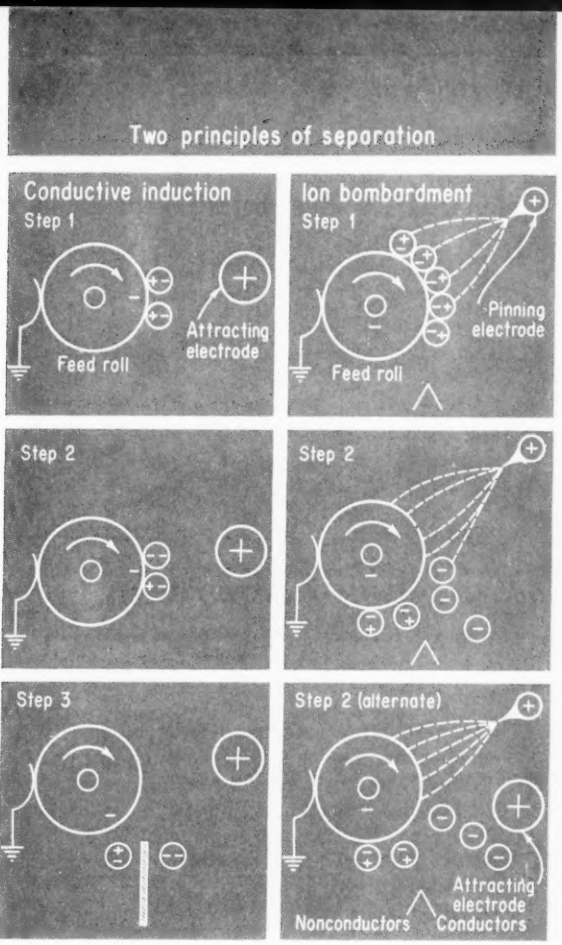


Progress in Electrostatic Separations

It's possible that the use of charge sign difference or charge potential difference can help you in your separation problems.

H. LESLIE BULLOCK, *New York*

One of the oldest industrial unit operations—electrostatic separation—can fire the imagination of the youngest economy-minded engineer.

Because of a flood of coincidental developments, there is renewed attention to electrostatic separations. Radio, television and radar have produced great improvements in the necessary electrical equipment. The science of solid-state physics has provided a means for forecasting results and techniques for altering the environment of charged particles in a mixture.

But at the same time as these steps forward in the state of the art, the increased cost of materials has made it imperative to reduce waste and scrap losses to a minimum. Widespread use of plastics, for example, has produced large tonnages of mixed scrap materials that can't be separated by old methods of separation.

Large volumes of potentially high-value plastic scrap, "dirty" mineral ores, and even mixtures of nut meats and shells are likely candidates for this separation technique. To separate the valuable product from the waste, using electrostatics, it is basically necessary only to have a difference in the sign, or the degree, of a charge on the two.

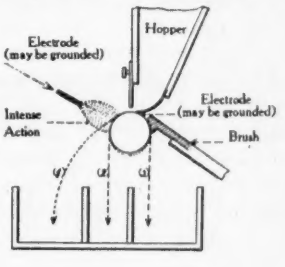
How Electrostatic Separation Grew

Dating back to the 1870's, electrostatic separation grew up in the mining industry, but its growth was slowed by lack of reliable equipment to produce the required high-voltage, unidirectional current. (The illustration below is from a 1910 issue of *Metallurgical and Chemical Engineering.*) By 1926, most basic patents, which had limited general development after mechanical rectifiers became available, had expired.

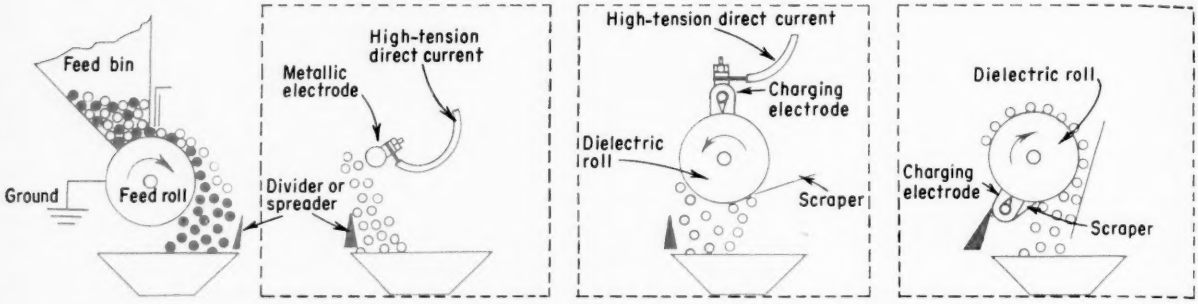
The advent of vacuum-tube rectifiers led to a reliable, compact source of high-voltage, unidirectional current. During the '30's and '40's, many advances occurred outside the mining industry, but for several reasons, progress was still relatively slow.

Diagram proves long industry interest

Fifty-one year old illustration, which appeared in this magazine, shows principle of ion-bombardment in electrostatic separation equipment.



Equipment for electrostatic separation by conductive-induction principle—Fig. 1



Grounded feed roll and the feed bin are common to three types of equipment shown to their right: (a) device that uses cylindrical attracting electrode; (b) one that has a revolving dielectric electrode; (c) same for light chaff.

There were three main roadblocks to application:

- Successful application depends on the passage of a thin stream of material through the electrostatic field. To produce even small tonnages, therefore, wide-faced machines had to (and still must) be used.
- Most machines had to be custom-built for a particular material.
- Limited knowledge of solid-state phenomena fostered erroneous ideas about intrinsic material qualities and charge behavior.

Four Ways to Separate

Since either a difference in charge sign or charge potential is fundamental to separation of mixture ingredients, let's consider the four ways to obtain one or the other condition.

Nature supplies the simplest. Two substances, separated after intimate contact, acquire equal and opposite electrical charges. If the two materials are dielectrics, the one with the higher dielectric constant becomes positively charged.[1] Though difficult to observe and determine because of fast, easy charge neutralization, the same thing happens when conducting materials are separated.

Charge differences may be produced, too, by heating, or by heating and cooling. In quartz, this forms dipoles; in potassium chloride and sodium chloride, charges migrate from a crystal of higher lattice energy to one of lower lattice energy to produce the desired difference.

The Third Way: Conductive Induction

Mix ingredients may also be charged by conductive induction. In this third method, a solid particle placed on a grounded surface between that surface and a charged conductor develops a surface charge. The sequence on the left at the beginning of this article depicts this schematically in three simplified steps.

Carried by the grounded metallic feed roll into an electrostatic field, any particle, conductive or nonconductive, is polarized (Step 1). A fraction of a second later, a nonconductive particle is still polarized, but a conductive particle has lost its opposite charge to the roll (Step 2). So when the roll carries the particles out of the field (Step 3), the polarized nonconductor sticks to the roll, the nonpolarized conductor drops under the attracting force of a charged electrode.

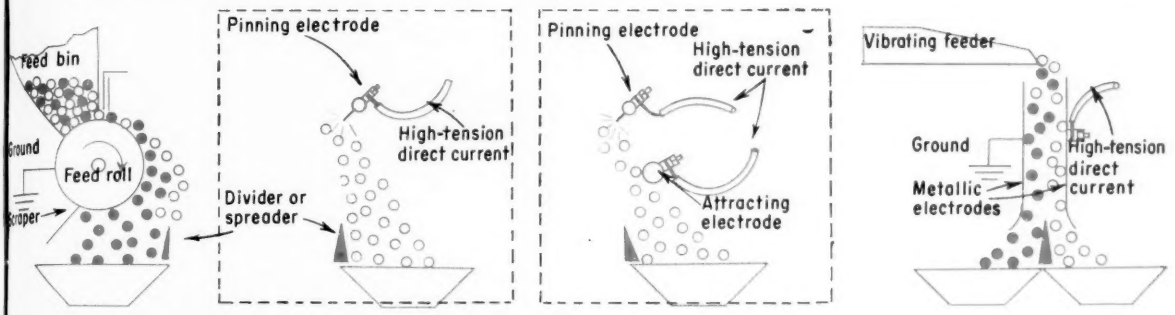
Where there is considerable difference of conductivity, this method is efficient. Where the difference is slight, however, the ratio of surface in contact with the roll to that uncontacted (and therefore able to maintain the opposite charge) becomes important. Varying particle configuration then affects separation efficiency.

Fourth Method is "Electrodynamic"

Ion bombardment, the fourth method of charging, increases the efficiency of separation of conductors from nonconductors. Because voltages of 30 kv. or greater are required to cause the flow of ions from electrode to particles, this method has become known as "high tension" separation. (This is really an electrodynamic rather than electrostatic method; there is an actual flow of ions from the charged electrode. But long usage has classified it as electrostatic.)

Consider the sequence shown at the right on p. 101. At a distance of 3-6 in. from a rotating feed roll, a pinning electrode emits ions along the indicated path to the grounded roll. This electrode may be parallel pins, a metallic brush of fine wires, a knife edge or a taut small-diameter wire. To obtain a sufficient discharge of ions, the electrode is held at a potential just under the sparking point; in a darkened room, a distinct corona can be observed.

Equipment for ion-bombardment separation—Fig. 2 . . . and that for free-fall—Fig. 3



With common elements at left, a pinning-electrode arrangement provides ion bombardment two ways: (a) with simple pinning electrode; (b) with attracting electrode added to up efficiency. At far right: a plate separator.

Any particle carried into the field by the feed roll is charged and becomes part of the circuit to ground. (Nonconductors are high resistances in this circuit; the potential drop across them is proportional to that resistance.) Step 2 shows, however, that as the roll turns the material out of the ion field, nonconductors continue to cling, conductors drop away. Because of their high resistances, the former retain the positive charge on their surfaces away from the roll; the latter, however, lose their charge differences fast after leaving the field.

The continued attraction of the nonconductors is sometimes called an image force, and it may be determined mathematically by solving Laplace's or Poisson's equation by inspection of symmetry conditions. For our purposes, it is sufficient to rely on the old rule that like charges repel, unlike charges attract.

Clinging of the nonconductor ceases as soon as its bombardment charge dissipates into the air or leaks off to the roll. Some materials drop from the roll rather quickly so that lines of fall of the conductors and nonconductors are not widely separated. If an attracting electrode is mounted, as shown in Step 2 (alternate), it pulls the conductor from the line of fall of the nonconductors to improve separation efficiency.

Differences in charge can, in addition to these four methods, be produced by photoelectric means. But this method works only for a few special materials.

Charge difference, for all these methods, should be at a maximum when the stream of material enters the separating electrostatic field.

Though major differences in charge may be due to thermal effects or induction, contact charges are always present. When they add to the difference in charge, rather than detract, the best results are obtained. Note that there are at least three sources of these contact charges in the movement of particles on themselves and on supporting and confining surfaces.

A Role for Science

With our increased knowledge of solid-state physics, we have been able to study the effects of environment on electrostatic separation. We now appreciate the real need for desliming, dedusting and drying of the contact surfaces. We know that surface coatings, such as those that may be deposited by slime and dust, in general supply a common surface to all the ingredients of a mix. The contacting surfaces of two different ingredients are made up of this common surface coating and are not chemically dissimilar, so that there is no difference in surface charge when the particles are contacted and parted in the moving mix. When all particles have a common surface coating, there is no difference in surface conductivity and hence there is no difference in behavior when subject to ionic bombardment in preparation for high-tension separation.

Moist surfaces are conducting surfaces, and it makes no difference whether the small surface charges, which we wish to use for separation, are generated by mechanical agitation, by conductive induction, by ionic bombardment or by the action of heat on the crystal structure; they are easily shorted out and neutralized by a moist conducting surface. A magnetic field will reach through a coating and attract any magnetic material in a particle, but an electrostatic attraction is a surface phenomenon. An electrostatic field will not operate if there have been no unlike charges generated by the separation of different materials or if previously generated charges have been neutralized in any way.

All elements of witchcraft and mysticism have been dispelled and, in any separating problem, we condition the physical and electrical background so that unwanted charges are eliminated and desirable charges fostered or produced, and so that the sign or intensity of the charges on the particles of the mix are at a maximum difference at the instant when the particles

enter the electrostatic separating field of the device.

What's Involved in Equipment

All electrostatic separators have certain design features in common. The feed must be uniform and should be in the form of a stream approximately one particle thick, to avoid masking of the charge or the physical carry-over of one ingredient by the other. The chutes and separating dividers should be proportioned to avoid bouncing of the material, as a bouncing particle may end up on the wrong side of the divider, irrespective of field attraction.

Accurate regulation of the electric power supply must be provided to give sufficient power to the separating electrode without producing an excess. Excess power may cause some conducting material to cling to the metallic feed roll in an ionic bombardment type separator, while in an attracting type machine, it may neutralize the charge on the attracted particle, electrify it with the same charge as the attracting electrode, and cause it to be repelled and to move back into the stream of material from whence it came.

All high-voltage surfaces and connections must be well-insulated or mounted in insulated enclosures to avoid sparking or possible injury to the personnel. Electrical power-packs should include overvoltage and excess current protection, should be protected against direct short circuits and should automatically connect all conductors to ground when the current is turned off.

Equipment for Electrostatic Separation

Line drawings in Figs. 1-3 show the different types of equipment used in electrostatic separation.

Common to all three types shown in Fig. 1 are the grounded feed roll and bin. Fig. 1a shows it combined with a cylindrical metal attracting electrode (such as that used in the old Huff machines). The metallic electrode may be stationary or revolving, and more than one electrode may be used with large-diameter feed rolls.

A revolving Bullock dielectric electrode,[2] shown in Fig. 1b, attracts heavy particles out of the line of gravity fall. The same electrode, Fig. 1c, rotating in the opposite direction, lifts light chaff and similar materials from the falling stream.

Advantage of this electrode is that the amount of surface charge can be precisely controlled by regulating the potential of the charging electrode. A particle can be attracted to the electrode without the danger that it will be recharged, with an opposite polarity, and attracted back into the moving stream of separated material. Also, a short circuit caused by foreign material contacting the electrode at any point won't short out the rest of the electrode surface.

To separate conductors from nonconductors by ion bombardment, the pinning electrode of Fig. 2a can be used. An increase in efficiency is gained by adding an attracting electrode, Fig. 2b.

Fig. 3 shows a plate, or free-fall, separator. Developed from a principle of early Cottrell collectors, this separator has the disadvantage that if finely divided material is present, closely held surface deposits tend to form and decrease separation efficiency. It has the advantage, however, that by carefully shaping the plates (so that square of the distance between them varies inversely with distance along the plane of symmetry) an isodynamic field is formed. This field produces uniform action over a greater distance of fall than is possible with other electrodes.[3]

Evidently never manufactured for sale, this separator was once proposed for mica and sand separation.[4] For certain specific separations, International Minerals & Chemicals Corp. developed the design in detail.

In the plate separator, the conditioned feed drops between the vertical electrodes in a thin, uniform stream. The charged particles are attracted to the electrode baring the opposite charge, but they must be oppositely charged before their introduction into the separating field. There is no selective charging or grounding action in the free fall.

Mineral separations still account for the highest tonnage of electrostatic separations. In the next two years, increased uses in beneficiation of iron ore should

What the manufacturers see as an electrostatic-separation rebirth

Two manufacturers offer these points

G. W. JARMAN, *president of Separations Engineering Corp., New York, believes that great advances in electrostatic separations are due in both mineral and nonmineral fields. These advances will come from use of equipment in which the electrostatic field can be closely adjusted, and from the application of solid-state physics principles. He reports such successful separations as quartz from calcite, plastics from plastics and nut meats from broken shells.*

Jarman has been in close touch with electrostatic separation for 32 years and has witnessed some strange developments. The most recent was the issuance of a patent on use of controlled heat in electrostatic separation, despite the detailed coverage of use of heated materials, heated electrodes and heated enclosures by G. W. Pickard before 1907, and despite a pilot-plant operation in 1932 to separate the same materials in the same temperature range.

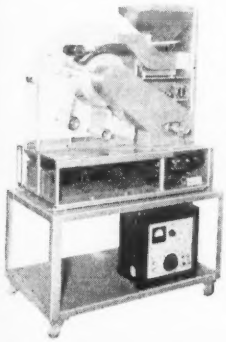
F. E. WOOD, *president of Sutton, Steele and Steele, Inc., Dallas, writes that he is enthusiastic about progress in the food industries, especially in the nut-cleaning field. He also looks forward to numerous applications in the separation of plastic scrap and to commercial developments in separating fibrous materials.*

Since many plants and laboratories need experimental separators, and since problems and their solutions vary with the materials, a single laboratory separator is usually of limited value. Accordingly Wood reports that his company will soon offer a laboratory unit for tests of all standard methods of electrostatic separation.

New equipment for ion-bombardment separation

In private correspondence, W. P. DYRENFORTH, technical director of Carpco Research & Engineering, Inc., Jacksonville, Fla., reports that the firm expects great progress in the mineral field through experimental work that will be done on its new laboratory high-tension separator (Fig. 4). Development work has demonstrated that different ores require different diameter feed rotors, as well as different voltage gradients. The new laboratory machine covers the range from 6-14 in. in diameter by 2-in. increments.

A back panel on the illustrated unit, which carries a grid and quadrant on a contrasting background, makes it easy to record all settings and is ideal for the use of high-speed photography in test work. A variable-speed drive with electronic tachometer, combined with fully adjustable electrodes and a wide range of voltage adjustment, makes this a versatile machine.



Self-contained laboratory device is one manufacturer's idea

ROBERT EVANS, *sales manager of Dings Magnetic Separator Co., Milwaukee, reports that his firm's biggest design change has been use of a 12-in.-dia. grounded rotor. Coupled with use of a sparkless needle-point electrode, this has produced exceptional separations of iron ores such as specular hematite. One Dings Coronatron laboratory separator, shown in Fig. 5, is entirely self-contained, with power-pack and vibrating feeder. Transparent plastic sheets, enclosing the working area, contribute to operating safety and avoid displacement of the falling streams of material by stray air currents.*

Some typical data

Quebec Iron Ore
(Pilot Plant) Clean specular hematite ore, no magnetite —20 mesh grind

Sample	Wt. %	% Fe	Distr. Fe
Head	100.0	38.2	100.0
Concentrate	53.8	69.2	97.5
Tail	46.2	2.1	2.5

Titanium Mineral Concentration
(Industrial Production) Concentrated beach sands (mesh 65)

Sample	Wt. %	% TiO_2	Distr. TiO_2
Head	100.00	46.74	100.0
Concentrate	74.96	61.75	99.0
Nonconductors	25.04	1.80	1.0

Scheelite-Pyrite Separation
(Pilot-Plant Study) Gravimetric and magnetic preconcentrate

Sample	Wt. %	% WO_3	Distr. WO_3
Head	100.0	45.6	100.0
Clean Scheelite	58.0	77.2	98.2
Clean sulfides	42.0	2.0	1.8

Dolomite

Sample	Wt. %	% SiO_2	Distr. SiO_2
Head	100.00	3.80	100.00
Concentrate	68.12	1.00	11.54
Middlings	20.09	9.70	33.00
Tail	10.84	30.20	55.46
Loss	0.95		

SiO_2 removal efficiency, 85.90%

Feldspar

Sample	Wt. %	% SiO_2	Distr. SiO_2
Head	100.00	74.30	100.00
Concentrate	70.34	67.56	63.57
Tailings	29.09	93.62	36.43
Loss	0.57		

add to this lead. Another active area is the recovery, cleaning and separation of abrasive grains.

In the plastics field, separation of ground scrap on the basis of difference in dielectric constant is an interesting application. Two mixtures have been tried out: separation of polystyrene from cellulosic acetate and of vinyl wire-insulation scrap from rubber.

Since this separation is made on the basis of difference in dielectric constants, it should be remembered that different formulations of the same plastic resin may have quite different dielectric constants. In highly filled stocks, the difference in kind and amount of filler may be more important than a difference in binding resin. For complicated scrap mixtures, it may be necessary to make several separations to obtain pure fractions.

In separating fine scrap copper wire from plastic and rubber insulation, the wire is finely chopped to release the copper from the insulation. The resulting mass is so intimately interwoven that it does not respond satisfactorily to the separating action of air tables or electrostatic separators. If this interwoven mass is screened on a vibrating screen of proper mesh, however, a pure concentrate of copper, contaminated with a small quantity of fine plastic or rubber, is obtained.

This concentrate may be cleaned up on either an air table or with an electrostatic separator. Fed uniformly to a separator, overs material on the screen is so low in copper ends and strands that the metallic particles are removed as a very clean concentrate. Plastic and rubber talings can, of course, be further separated.

Plant Layout for Electrostatics

If adequate separation can be obtained with screens, jigs, air separators or flotation cells, it is usually more economic to use them rather than electrostatics. But full consideration should be given to electrostatic separation where:

- Valuable materials can be recovered that would otherwise be lost.
- Subsequent operations can be made more efficient by the more-complete cleaning of a product.
- Better grading will allow a material to command a higher price.

Combinations of equipment often permit optimum results with an electrostatic separator of small capacity. If the percentage of valuable material in the feed is high, then air tables, screens and other separators (air, magnetic or gravity) can be used to produce a high-quality concentrate and a tailings material rich in the valuable product. Electrostatics can then separate the valuable product from the tailings, either as first-grade material or as a middling product that is returned to the main feed.

If the percentage of contaminating material in the feed is high, air tables and similar equipment can produce a worthless tailing product and a concentrate of good material that is rather highly contaminated. The electrostatic separator can then part contaminants from the valuable material.

If valuable material and contaminants are present in fairly equal amounts, the air tables can be "tuned" to give a high-grade concentrate, a worthless tailings and a middling product too low in value to return to the feed. This third stream, cleaned up by an electrostatic separator, can be returned to the feed.

Many combinations of equipment and sequences of operations are possible. Aside from ion-bombardment separation, which depends entirely on conductivity differences, most electrostatic separations are reversible. By changing the sign of the charge on the attracting electrode, the ingredient present in least amount can be pulled over, and this usually results in greater recovery and purity.

Some Remarks on Safety

Careful thought should be given to safe operation of electrostatic separators. Though great emphasis is put on low current ranges (milliamperes) at the high operating voltages (up to 40 kv.), an electric shock from this equipment causes quick, violent muscular contraction. It may be fatal for a weak heart, and secondary damage might occur should it cause the body to contact moving parts of the machinery.

All parts of the separator, other than electrodes, should be permanently grounded. It is well, too, to include an automatic switch in the power-pack circuit to ground out the electrode circuit when power is off. This guards against residual charges that may be heavy where operating voltage is high and area of the electrodes and their connecting lines permits a high-capacity effect.

Proper safeguards must be taken, of course, where flammable or explosive dusts or solvents might be encountered. Do not rely on the so-called sparkless electrodes alone; even they can induce charges of sufficient potential to produce dangerous sparks. (Or sparking can occur from the connecting high-potential wiring.) The only real safeguard is proper and sufficient ventilation, and dust and fume collection, to keep concentrations below the explosive range.

Special Dangers to Watch

Electrodes, especially of the spray or ionic type, should never be placed where they can radiate to an ungrounded metallic structure or to the surface of a moving dielectric like a nonconducting belt. If allowed to radiate to the former, potential may build up to a point where sparking to the nearest grounded conducting surface takes place. The potential may also approach that of the electrode, and the charged body then constitutes a source of danger.

If allowed to radiate to a moving dielectric surface, charges are mechanically conveyed to another location. There, either sparking may occur or a Van de Graaff effect may build up high voltages on an insulated conducting surface.

Electrodes should never be adjusted while current is on. And if an automatic grounding switch is not provided, electrodes should always be grounded out by a ground rod or contact bar before adjustments are made. Grounded metallic screening with small-enough mesh to bar a hand from entering provides an excellent out cover for the unit. Still it permits visual checking of the operation, good ventilation for the unit.

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4. Correspondence, H. L. Bullock, Technical Sales Corp., and E. G. Loomis, June 2, 1931.

Meet the Author

H. LESLIE BULLOCK *is a licensed professional engineer with his own consulting business in New York City. A prolific author of technical papers and articles over the years of his practice, he was last represented in the pages of* CHEMICAL ENGINEERING *by an article on modern methods of solids preparation (Apr. 20, 1959, p. 177).*

Interested in electrostatic separations even before the establishment of his consulting business in 1934, Bullock has also had a wide range of industrial experience with process industry firms since his studies, in mechanical engineering, at Columbia University.

In addition to the presentation of technical papers before such organizations as the American Chemical Society, American Institute of Chemical Engineers and the Technical Assn. of the Pulp & Paper Industry, Bullock has lectured at Columbia and at the Massachusetts Institute of Technology. He is a member of ASME, SPI, American Ordnance Assn. and National Panel of Arbitrators.

Estimate High-Vacuum Costs Graphically

High-vacuum technology has reached the point where you may be considering its use in your process. If so, here are aids to preliminary system design and cost estimation.

CHARLES H. NAUNDORF, *Consolidated Vacuum Corp.*

As vacuum systems and equipment of increasing sophistication have been developed in recent years, the use of high vacuum for a processing tool has mushroomed. This article will take an up-to-date look at high-vacuum pumping systems and will provide the process engineer with means for finding the relative costs of these systems. The information is presented graphically for quick calculation.

Complex modern systems can simulate outer space conditions—pressures of 10^{-8} to 10^{-7} mm. Hg—in chambers as large as 25 ft. in dia. These systems employ such techniques as ionic, cryogenic and getter pumping, as well as heating of the chamber walls for accelerated degassing.

We will confine our discussion, however, to the more usual chamber diameters of 2—6 ft. and to diffusion pumping and ambient wall degassing.

When discussing high vacuum, it is usual to use units of absolute pressure. No longer do we refer to "inches of vacuum"—instead we speak of millimeters of mercury absolute pressure (mm. Hg). In some pressure ranges, it is convenient to use microns (μ) of Hg, or just "microns." By definition, 1,000 μ = 1 mm., both being units of length. The suggested international standard term to replace the British "mm. of Hg" is the word "Torr"—in honor of Torricelli, a physicist.

Vacuum gages indicate absolute pressure in microns and mm. Hg and, since the gas density in the chamber volume covers such a wide range, the pressures are often shown by decades, such as 10^{-3}, 10^{-4}, 10^{-5} mm. Hg. Vacuum-pump characteristics are usually plotted as a function of these pressures.

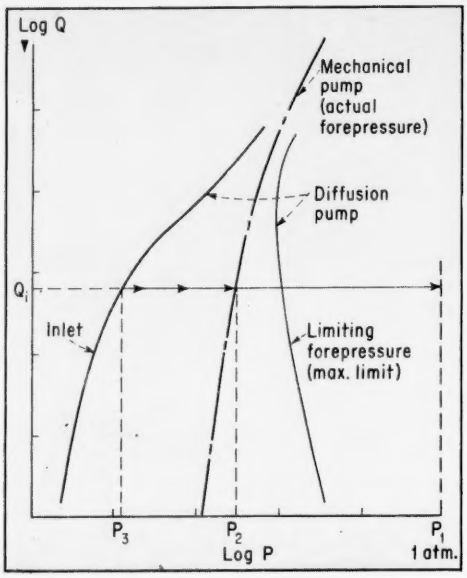
Characteristics of Pumps

There are many types of pump available to the vacuum engineer, depending on the service. Some of these are—for

Roughing—Steam ejectors
Mechanical sliding-vane pumps
Mechanical positive-displacement blowers
High vacuum—Diffusion-ejector pumps
Diffusion pumps
Ionic pumps
Getter pumps
Traps—Cryogenic traps
Absorbent (Zeolite) traps

Two kinds of characteristic curve[1] are used for vacuum-pumping components. One, the speed curve, is a plot of pumping speed vs. pressure, and is most often used by pump designers and for calculations involving conductance. Speed is defined as the volume of gas removed from the system per unit time—it is usually expressed in liter/sec.

The throughput curve is a plot of flow Q (defined as $Q = SP$ and expressed in μ-l./sec.) vs. pressure P. It is used to match the capacity of one component to another and to trace the gas flow through the system. With this curve, it is easier to visualize the pumping sequence and follow the pressure change at a particular flow rate as it progresses through a system of pumps and pipes.



Typical curves show relationship of gas load and inlet pressure—Fig. 1

Fig. 1 is a typical throughput curve. As the gas enters the diffusion pump, it is propelled forward and compressed by the jets. The diffusion pump exhausts to the mechanical pump, which finally discharges the gas to atmosphere. The limiting forepressure curve shows the maximum pressure against which the diffusion pump will discharge.

Diffusion pumps range in nominal size from 2 in. to 32 in. in dia. The corresponding peak speeds ($Q/P = S$) range from 108 to 52,000 l./sec., or 228 to 110,000 cu.ft./min. The lead photograph shows a group of jets, ranging from the smallest to the largest.

Selecting and Designing a Pumping System

The process requirements that must be known before selecting a pumping system are:

- Gas load variation (chamber outgassing[3] and/or the gas evolution from the process materials).
- Pressure range required.
- Cycle time desired.

Ideally, all this information can be determined, and pump selection consists simply of comparing the requirements with the characteristics of the available pumps. In practice, however, one or more of these factors is often indeterminate, and other peculiarities of the particular application may also influence the selection.

All vapor pumps require mechanical backing pumps to produce the necessary forepressure and, therefore, high-vacuum pumping systems normally include at least one pump of each type. In general, the type of vapor pump depends on the ultimate pressure, and the size depends on the capacity needed to meet process requirements. Forepump size depends on both maximum gas load and allowable cycle time.

Gas load variation is the most difficult factor to determine because it is hard to know the outgassing load from different materials at different temperatures. The vapor pressures of gases and molten metals at various temperatures help to determine limitations or extremes of these loads. The best process information is laboratory data from small prototype equipment, which can be extrapolated.

To fully appreciate the various ways in which components can be placed in a system, the designer must become thoroughly familiar with speed and throughput curves. All manufacturers supply this literature.

Fig. 2 schematically illustrates the most generally used pumping system. The mechanical pump performs the two functions of roughing and backing. The smaller mechanical or "holding" pump maintains a guard vacuum for the vapor pump. With the system in standby condition, all valves are closed except the valve ahead of the holding pump, which is left open all through the cycle, and is closed only on complete shutdown or for testing the holding pump itself.

To start evacuation of the chamber, the roughing valve is opened. When the pressure is low enough for operation of the vapor pump, the roughing valve is closed and the forepressure valve is opened. This readies the backing pump for use behind the vapor pump when the high vacuum valve is finally opened.

The gas load from the chamber is now handled by the vapor pump, which discharges it to the backing pump, which in turn discharges it to the atmosphere. Before the chamber is bled to atmospheric pressure, the high vacuum valve is closed, followed by the forepressure valve. The system is now on standby.

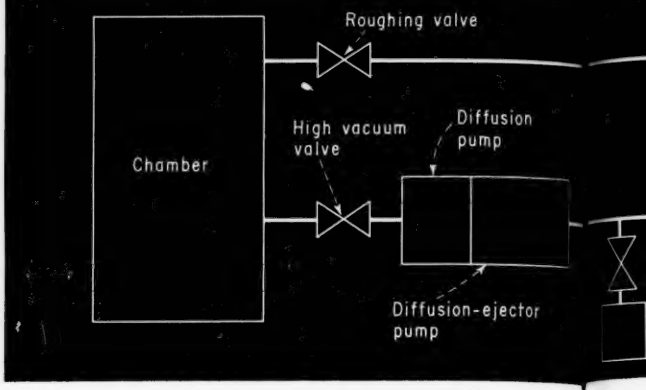
We have briefly reviewed the basic components and system design. What can the designer do to choose the most economical approach? The best system should be selected from two or more that satisfy the needs.

Determining Capital Costs

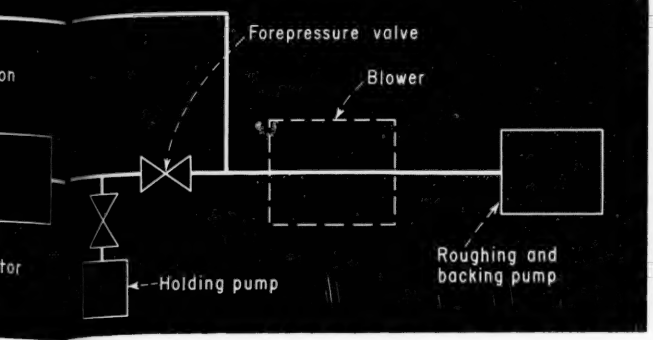
As Fig. 3 shows, each type of pump operates over a different pressure range, and the problem for the user is which pump or combination of pumps to select. Quite often, one of a number could be chosen from a capability standpoint alone.

Fig. 4 shows throughput curves for four family

Schematic arrangement of pumps needed in a



eeded n a typical system – Fig. 2



types. These curves are marked with the corresponding average cost to the user, and the legend shows the required backing system.

Nomenclature in this and subsequent figures is as follows: for mechanical pumps, *KS*, *KDH* and *KD* are the Kinney Vacuum Div., New York Air Brake Co., model designations, and the numbers represent the peak speeds in cu.ft./min. For blowers, *VPR* and *VPRG* are the Heraeus Co. model designations, and the numbers are peak speeds in cu.m./hr. For diffusion-ejector pumps, *KS* is the Consolidated Vacuum Corp. model designation, and the numbers are peak speeds in l./sec. For diffusion pumps, *PMC* is the CVC model designation and the numbers are peak speeds in l./sec.

The costs of Fig. 4 are total capital costs for each pump system, including electrical equipment, piping, controls, valves, labor, etc. They are estimated for simple, functional designs. Installation costs are not included.

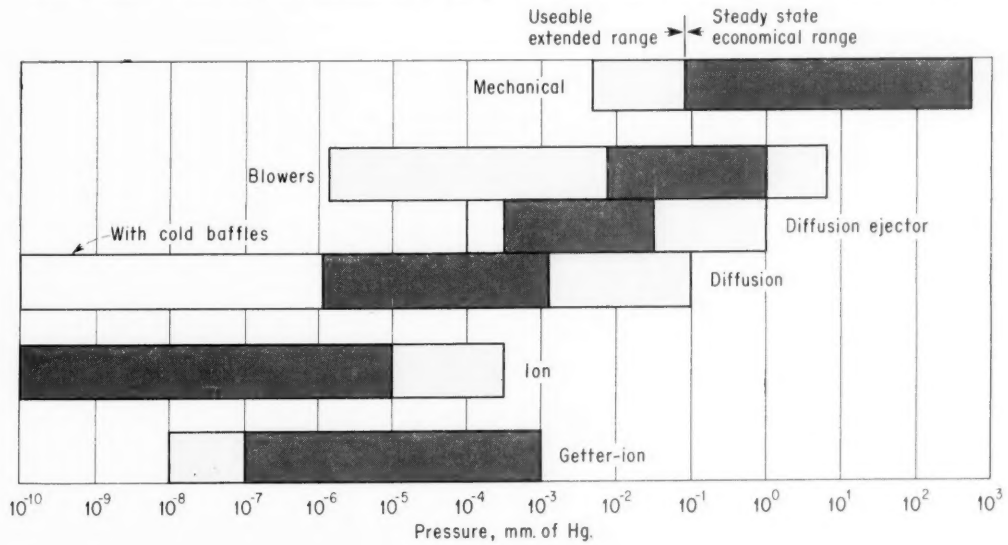
To compare the pump families, the curves are superimposed, and points of equal cost are plotted, interpolating or extrapolating where necessary. These form the economic bands shown in Fig. 5. If the gas load and operating pressure are to the left of the economic band, we would choose a system from the family whose major capacity lies to the left, and if the point is to the right, we choose a system to the right of the economic band.

The clear areas of Fig. 5 are the best economical steady-state regions for the pump type within them. The shaded areas show where a change from one type to another can occur—the heavy shade where the change should be made, the light shade where further study is needed.

Need for a choice between a diffusion and a diffusion-ejector pump is unusual because the former can produce more speed for the same investment than can the latter. For equal peak speeds, the diffusion-ejector requires a larger backing pump because it is designed for higher maximum gas load at higher pressures. The economical point at which to use the diffusion family occurs as soon as the gas load and pressure are within their operating range. These pumps can be used in the transitional area, which extends from the limiting forepressure down to 0.5-2.0μ, where peak speeds occur. Diffusion pumps should not be used continuously beyond the right side of the heavy shade of the economic band, where the maximum speed falls on rising pressures.

Blowers are used to great advantage when roughing down a chamber. They can be started at 10 to 50 mm., and can also take sudden exposure to atmospheric pressure in the event of a power failure. As the clear area shows, blowers do not offer much economic advantage for steady dynamic pumping, but they are

This chart shows performance range for the different pump types—Fig. 3



flexible and do not require very complicated piping.

The economic band for blowers vs. mechanical pumps is more complex. Lubricating oil in a mechanical pump, Fig. 4a, often becomes contaminated with water or other liquids that, when exposed to the vacuum, become volatile and reduce net pump capacity. The family of curves is from catalog data based on McLeod gage readings. The two Pirani gage curves illustrate, for one of the family, the effect of (1) clean oil vapor pressure and (2) contaminated oil volatiles on pump capacity. All other pump components in the system depend on the mechanical pump curve which, therefore, must be chosen with the whole process in mind.

Blower or KS-type booster pumps (Fig. 4b & c) are often used for additional capacity in the important pressure regions. The characteristic curves for blowers are affected by the actual capacity of the mechanical pump, and shift in a similar manner. The KS pumps are unaffected because their discharge pressures exceed the pressure range of the contaminated mechanical pumps.

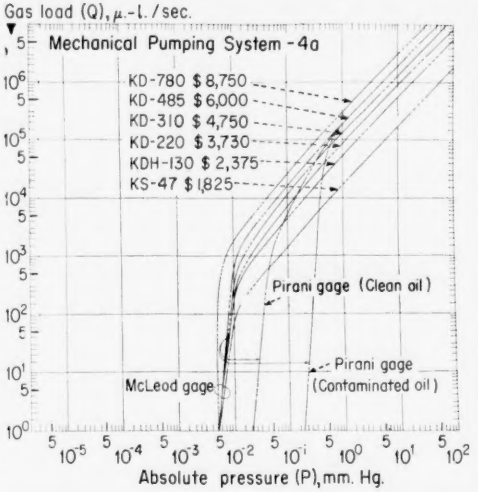
There are many ways to control volatiles, such as cold-surface trapping, addition of a booster or continuous oil purification. Special attention is needed if the volatiles make up 25% or more of the gas load. Consult the manufacturers' literature.

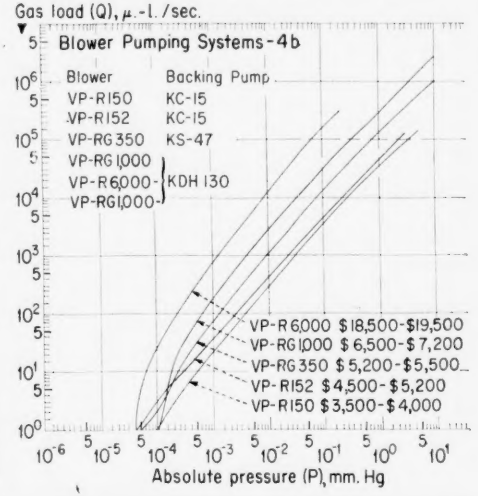
We have considered steady-state dynamic flow conditions at a particular pressure. But we are also concerned with cycle time. The simplest cycle is pumping down to a particular pressure, performing the reaction and returning to atmosphere. Typical of this case is an industrial coater for decorative finishes, where the pressure is usually lowered to 0.5 μ before aluminum is flashed onto the plastic parts.

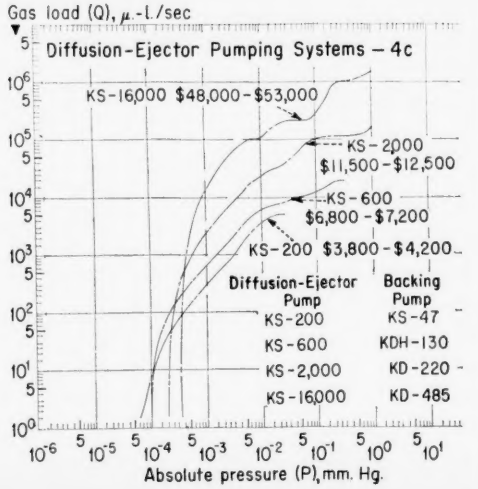
The gas load is determined from the outgassing of the chamber walls, and of the volatiles from the plastic pieces. This load establishes the diffusion pump required. The remaining question is "What size roughing pump?" It can be equal to or greater than the minimum dictated by the diffusion pump characteristics. One of many useful ways to calculate roughing time is the pressure vs. time curve, Fig. 6.

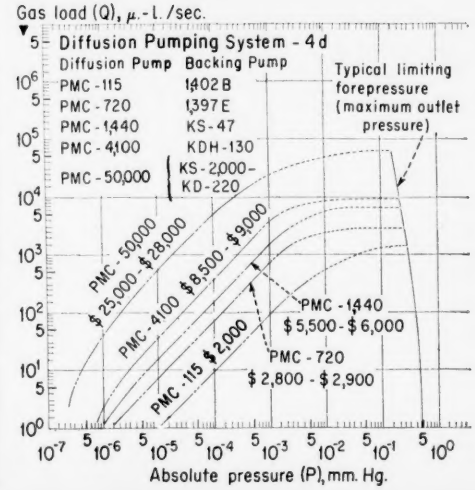
The relationship for calculating roughing time is:

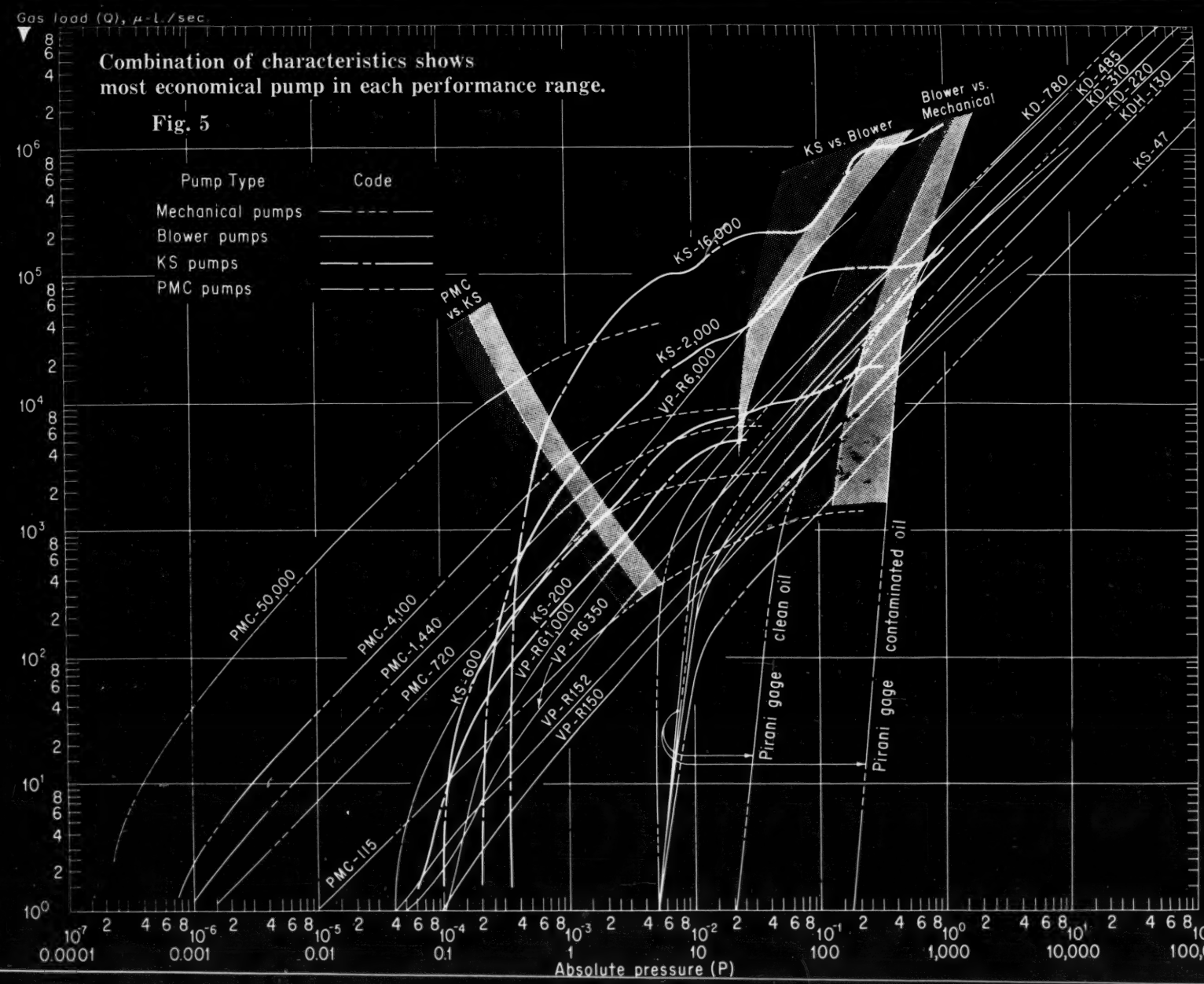
Characteristic curves show performance of the various pumping families, as well as system cost and type of backing pump required—Fig. 4





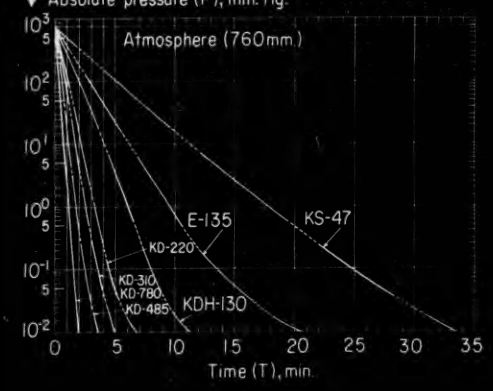




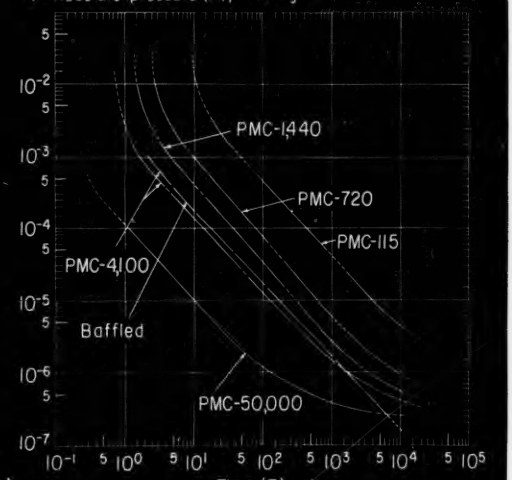


Chemical Engineering, October 2, 1961

▼ Rough pumping time per 100 cu. ft. – Fig. 6



▼ Absolute pressure (P), mm. Hg.



High vacuum time per 100 sq. ft. – Fig. 7 ▶

$$t = V/S \ln(P_s/P_f)$$

where P_s and P_f are the starting and finishing pressures, t is the time to reduce the system pressure from P_s to P_f, S is average pump speed between P_s and P_f, V is the chamber volume.

Fig. 6 avoids this calculation. Each pump is shown evacuating a 100-cu.ft. chamber, so that, if we are considering a 256-cu.ft. chamber, we merely multiply the time from the chart by a 2.56 factor.

Most of the cycle time in our decorative coater example is a necessary evil and the actual process, aluminum flashing, is only a small part of the total. The economical roughing time is found as follows:

The chamber and its fixtures constitute a fixed cost, and the pumping system a variable cost, depending on size and capacity. Suppose, for example, that the system consists of two PMC-4,100's with associated fixtures, and is worth $17,000, including the smallest allowable roughing pump. Two KDH-130's are indicated and one KD-220 is the minimum. For this system, the roughing time from 760 to 0.2 Torr (200 μ) is 11 min., and the assumed diffusion pumping time from 200μ to 0.5 is given as 2.5 min.

The question arises, "Should we put a bigger roughing pump in this system to reduce cycle time?" Suppose, for example, that we consider a KD-310 mechanical pump. This pump will cut 2.4 min. off the roughing time and will cost $1,020 more than the KD-220.

Whether or not this added investment is justified depends on the money value of time in our particular process, and the desired payout for our investment.

The high vacuum part of the cycle can also be shown as a P vs. T chart, see Fig. 7. The major gas load does not come from the original gas volume but from outgassing of the walls, fixtures and work pieces in the chamber. The high vacuum evacuation, then, is dependent on the type and area of material exposed in the vacuum space. Accordingly, Fig. 7, which starts at 100μ, is based on an area of 100 sq.ft. Divide other surface areas by 100 to get an approximate factor.

A high vacuum calculator is available that allows direct computation for a particular area, and shows the number of diffusion pumps needed for larger chambers.[3] This time-saving calculator is applicable to process evaluation and analysis, when the gas load is not pressure-dependent.

Determining Operating Costs

Total operating costs for vacuum systems are made up of floor space, labor, utilities, oil changes, maintenance, etc., all of which are variable. We will consider only utilities cost, using as a base $0.02 per kwh. for electricity and $2.80 per 1,000 cu.ft. (7,500 gal.) for water.

Mechanical Pumps	Utilities Cost, $/Hr.
KS-27	0.03
KS-47	0.04
KDH-130	0.10
KD-220	0.20
KD-310	0.31
KD-485	0.51
KD-780	0.82
Blowers	
VPR-150	0.012
VPRG-350	0.067
VPRG-1,000	0.177
VPR-6,000	0.289
Diffusion-Ejector Pumps	
KS-200	0.050
KS-600	0.103
KS-2,000	0.337
KS-16,000	2.550
Diffusion Pumps	
PMC-115	0.0075
PMC-720	0.030
PMC-1,440	0.055

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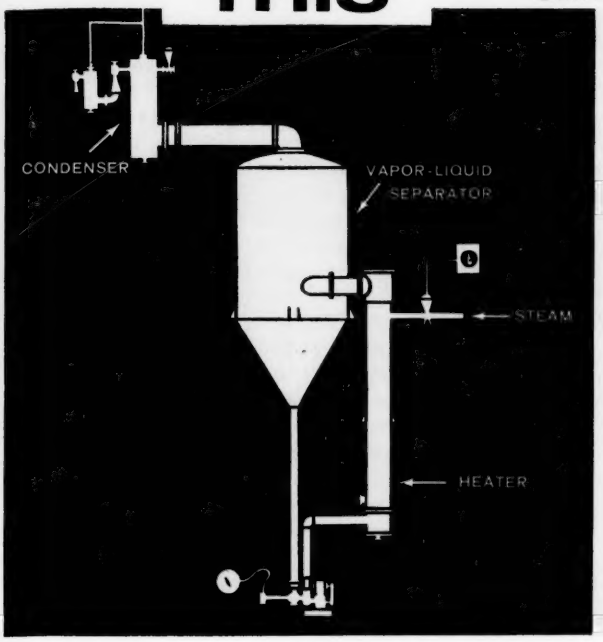

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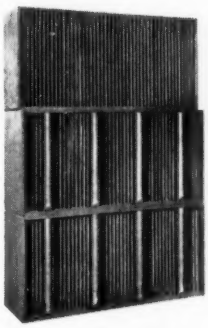
"Karbate" Entrainment Separator **(Line Type)** View from downstream end showing collector.



"Karbate" Entrainment Separator **(Module Type)** Downstream view of assembly of 12 modules with side plates.

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PMC-4,100	0.147
PMC-50,000	0.537

To determine over-all utility cost for a system, add the costs for each pumping component.

Selecting the Pumping System

Before choosing a vacuum system, analyze the process needs and consider the following items:

- Dimensions of process vessel.
- Pressure required (maximum and ultimate).
- Time cycle desired.
- Gas load (condensable and noncondensable).
- Process hazards if oil, water vapor or air diffuse or migrate into the vacuum chamber.
- Tolerable inleakage (1% or less than system capacity near ultimate pressure).
- Utility rates.
- Floor space and headroom available.
- Services available—electricity (voltage, phase and cycle); cooling water (temperature and flow); air (50-60 psig. normally required).
- Operating hours per day.

Time cycle and gas load can sometimes be combined into a load-time pattern.

After the various items affecting pumping capacity have been considered, it is wise to use a safety factor —3 to 4 when the gas load is theoretically determined, 1.5 to 2.0 when data is from the laboratory.

To illustrate, let us consider two specific examples:

1. Chamber evacuation: Consider a chamber 6 ft. in dia. by 8 ft. long; an ultimate pressure (at cycle end) of 1 x 10^{-6} mm. Hg.; an allowable cycle time of 5 hr. or 300 min.

The chamber has a volume of 226 cu.ft and a total area of 207 sq.ft. The volume factor is 2.26 and the area factor is 2.07. Fig. 6 and 7 show a number of possible choices for roughing and high-vacuum pumping. Assume various time combinations as follows:

High Vacuum Pumping, Min.	Rough Pumping, Min.	High Vacuum, Adjusted	Roughing, Adjusted
200	100	100	44
270	30	130	13
290	10	140	5

Fig. 7 shows that 130 min. of high-vacuum pumping would require one PMC-4,100. In other words, the equivalent chamber (100 sq.ft.) is reduced to 1 x 10^{-6} mm. in 130 min. by one PMC-4,100 diffusion pump. Fig. 6 shows that 13 min. of rough pumping requires a KDH-130 mechanical pump, which is the recommended pump for use with a PMC-4,100, see Fig. 4d. Cost is $8,500-9,000.

2. Process gas loads: If, in the same chamber, there were a process with a dynamic gas load, the problem would change. Assume that ten work pieces are tested in the laboratory and, when they are heated, the gas load increases to raise the pressure to 10μ with a KS-200 pumping system. After cooling, the pressure is 0.2μ. The chamber ultimate was 1 x 10^{-6} mm.

The larger chamber will hold 200 work pieces, and lowering the final pressure below 0.2μ will increase quality. The KS-200 system handles 3,000 μ-l./sec. at 10μ and 40μ-l./sec. at 0.2μ, see Fig. 4c. The new 200-work-piece chamber calls for a 20 times increase in pumping system. This means 3,000 x 20 = 60,000 μ-l./sec. at 10μ, and 40 x 20 = 800 μ-l./sec. at 0.2μ.

A KS-2,000, Fig. 4c, will handle 20,000 μ-l./sec. at 10μ, and three such systems cost less than one KS-16,000 system. The final 800μ-l./sec. load handled by these three (each handles 266) produces 0.3μ.

A PMC-50,000, Fig. 4d, will produce a final pressure of 0.016μ. A safety factor to allow for conductance losses and extrapolation of the laboratory data indicates a final pressure of approximately 0.04μ.

The cost of the PMC-50,000/KS-2,000/KD-220 system will be $28,000. The other two KS-2,000/KD-220 systems will cost about $24,000, for a total of $52,000. Final piping arrangement, special electrical needs, controls, etc., can affect the actual total cost.

This presentation allows graphical computation of roughing and high vacuum pumping time, as well as estimation of capital and operating costs for various high vacuum systems. Final design details should be left to an engineer well versed in vacuum technology.

The author wishes to acknowledge the assistance of J. Pavel and R. Lucey on calculations and graphs.

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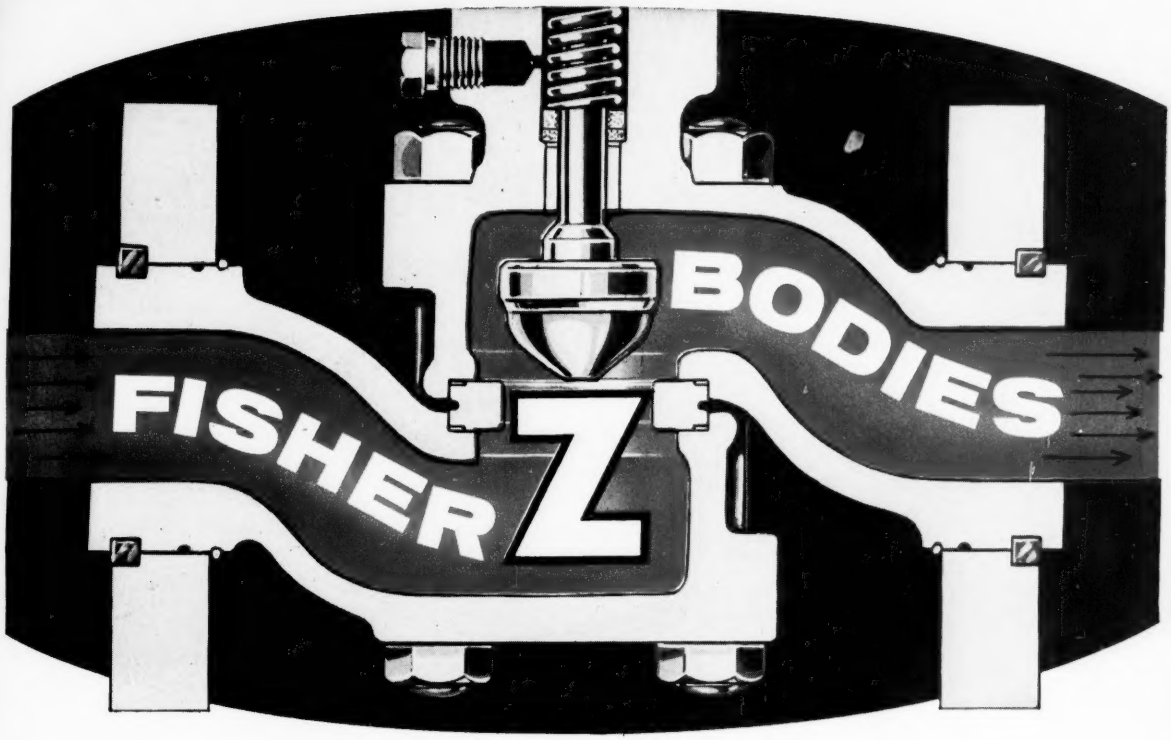
Meet the Author

CHARLES H. NAUNDORF, *manager of special systems and modified standards for Consolidated Vacuum Corp., Rochester, N. Y., has made his entire career in the field of vacuum technology. An engineering-physics graduate of the University of Tennessee (B.S., 1951), he first worked with Eastman Kodak in Rochester as a project engineer for general vacuum systems. The following year, he moved to CVC as manager of a small engineering section working on special problems of customers. His group has grown with the industry until, today, it has the facilities to design, fabricate and install all types of vacuum systems.*

Naundorf is co-holder of a patent for a continuous vacuum melting and casting device, and also developed the calculator described in his article. He is a member of Tau Beta Pi and the American Vacuum Society.



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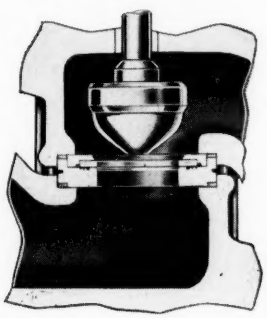

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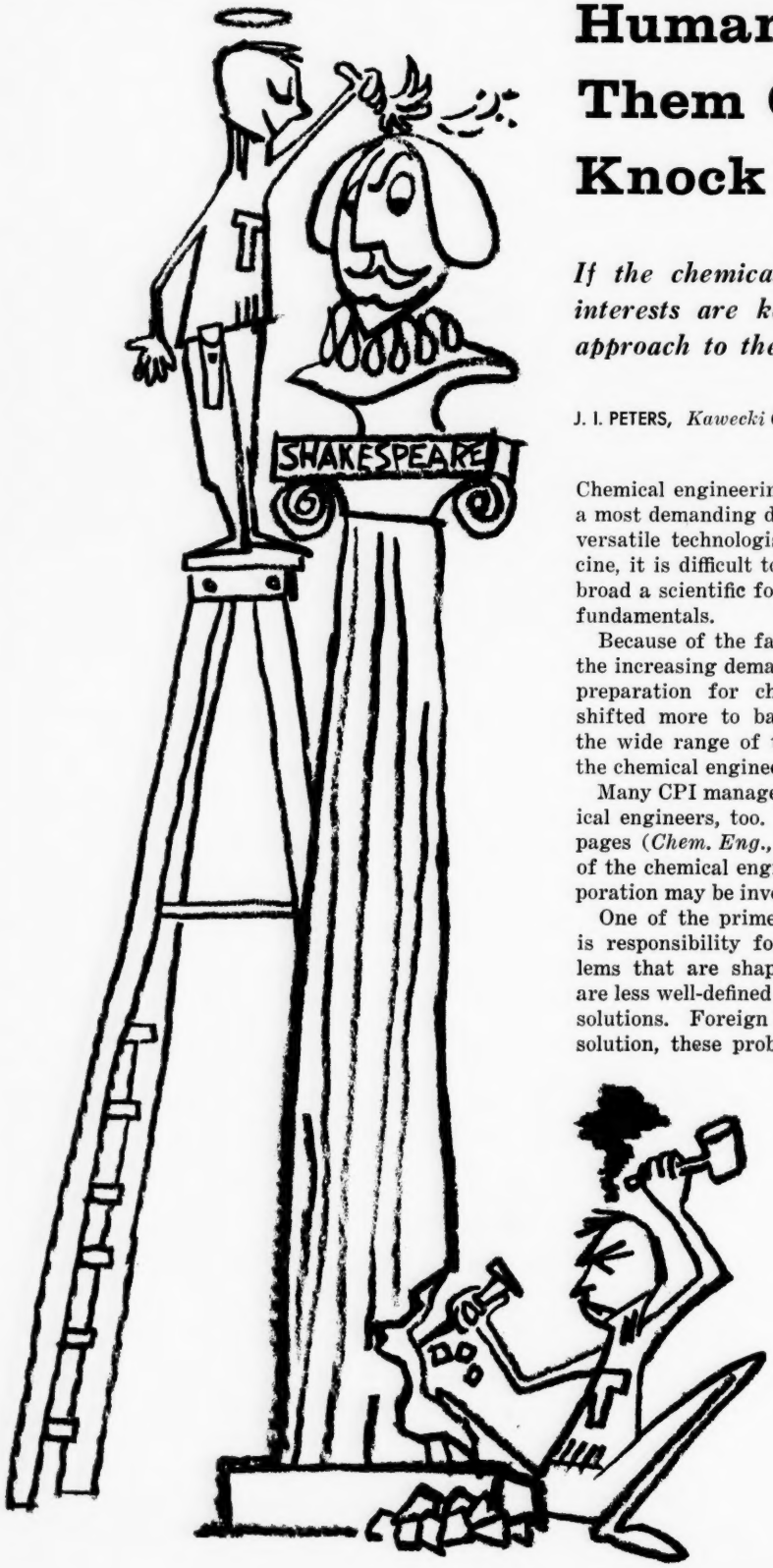

Humanities: Dust Them Off, Don't Knock Them Down

If the chemical engineer's attitudes and interests are kept in mind, a significant approach to the humanities can be found.

J. I. PETERS, *Kawecki Chemical Co.*

Chemical engineering, in its short tradition, has been a most demanding discipline—one designed to produce versatile technologists. With the exception of medicine, it is difficult to think of any other study with as broad a scientific foundation, as great an emphasis on fundamentals.

Because of the fast pace of modern technology, and the increasing demands of process industry economics, preparation for chemical engineering practice has shifted more to basic concepts. This shift reflects the wide range of technical responsibilities in which the chemical engineer may find his work.

Many CPI management jobs have opened up to chemical engineers, too. As Howard Bunn noted in these pages (*Chem. Eng.*, Nov. 14, 1960, p. 240), nearly half of the chemical engineers in the modern chemical corporation may be involved in managerial functions.

One of the prime roles of the manager, of course, is responsibility for the work of others. The problems that are shaped for the manager in this role are less well-defined than the technologist's, have many solutions. Foreign to the latter's search for a unique solution, these problems demand a broader approach

Meet the Author

J. IRWIN PETERS is in the sales development department of Kawecki Chemical in New York. Educated in mechanical and chemical engineering at the University of London, he also has a degree in economics from the University of Delaware. Besides engineering experience in Britain, he has worked for Du Pont in the U. S. in both plant and R & D functions. Peters is a member of AIChE.

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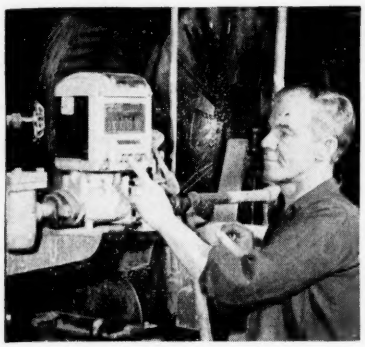

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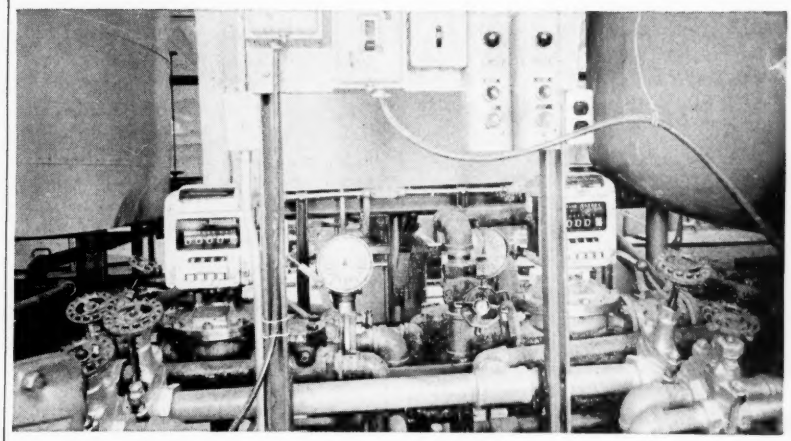

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than do the technical ones. At the same time, however, even the solitary worker—with no managerial function—benefits from an appreciation of how these ill-defined problems affect him and his job.

Another role that confronts the chemical engineer is the contribution that he can make to civic welfare. Here, some have found their professional realms have placed them in an excellent position to interpret science and technology for the layman. This role of communication, like that of the managerial function, calls for less constriction in thinking than does the technical role of the engineer.

What Job for Education?

This one-man triumvirate—engineer, manager, citizen—requires a good education. Are the universities preparing engineering students adequately? The answer unfortunately appears to be no.

Sound education in the humanities is essential for the engineer as a responsible citizen and as a potential manager. It is essential to enable him to prepare his company for future growth, to help him foresee the future of his industry, to function happily and effectively as a professional man.

Now, why should I emphasize the value of humanities? You might claim that the mental discipline of the physical sciences fosters the same qualities of imagination and perspective as the liberal arts. Of course it does. But it is directed primarily at the physical world and does not help you understand people or develop values.

Unlike those who form their philosophy, or set of values, from personal experience, the liberally educated man can lay his philosophy alongside those formed by great thinkers and events of the past. Benefiting from mankind's experience, his philosophy can be better thought out and more comprehensive.

Furthermore, in technology there is one optimum answer to a problem. In the social sciences and humanities, more than one answer may be good or correct. The best answer is very difficult to obtain, even if it exists. Without a proper study of these broadening disciplines, the engineer may be intolerant of answers other than his own.

Humanities for Technologists

If it is agreed, then, that a broader preparation is necessary for the broader, nontechnical aspects of the chemical engineer's career, how can this best be accomplished?

First, let's consider what might be included in the "humanist" training. Opinions differ, but I think the best list might include philosophy, history, literature and the fine arts. Though I will develop the reasons for including these, the particular subjects are not really critical—these and many others, such as languages, religion and social sciences, contribute toward a liberal education.

Ralph Barton Perry, the Harvard philosopher, has made the point well: "Education is liberal insofar as it invites and qualifies men to choose deeply and fundamentally, to choose ends as well as means, to choose remote as well as immediate ends, to choose from many rather than from a few possibilities . . . If it is asked why these studies are liberating, the reason is that they stimulate the imagination, create perspective and breadth of outlook, and thus call into play the faculty of choice."

Philosophy is the most frequently neglected study in the liberal arts. The reasons for this are its difficulty, its lack of appeal to young people and the attitudes of many of its professors. As one philosopher, Robert Laursen, has noted, "We philosophers rest smugly in the knowledge that we are not as narrow as the scientists . . . nor as stupid as the professional educators. We look down our noses at historians and chemists. Let there be no misunderstanding—we are intellectual snobs."

But philosophy, despite its difficulties, determines your treatment of family, friends and enemies. It determines your conduct and attitude toward your home, work and country. And it influences your religious beliefs, ethical standards, social adjustment and personal happiness.

Philosophy for Chemical Engineers

Chemical engineers, who work on problems of only a small part of the world, are in as great a need as others to view the wider world. Used to abstractions and theory, sound evidence, and accurate thinking, they are well-disposed to philosophical thinking.

To approach philosophy, I believe that the student might first learn a few fundamental philosophical concerns in ethics, social and political philosophy, religion and esthetics. Such a one-semester preparatory course is desirable, because most students enter college without an acquaintance with philosophy as a discipline.

Neither the history of philosophy nor a systematic presentation of its branches should be studied. As ends in themselves, studies of Aristotelian metaphysics, Hegelian dialectics and Berkeley's pragmatism are of little value. Rather, a few major philosophical problems should be analyzed with a view to provoking the student to think in light of what the great philosophers contributed.

Standards of judgment, possibilities of human capacity, the need for ethics, types of ethical theory, the problem of human life in society, what religion is and does, and the problem of evil—all these should be considered. But ideas of outstanding philosophers should, let me reemphasize, help illuminate these areas, not themselves be objectives of the study.

History, To Find Out Where We Are

To understand the present, one must know and understand the past. Historical studies help such un-

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understanding, deepen perspective in today's problems.

Wrote Robert Heilbroner, last year: "At bottom, our troubled state of mind reflects an inability to see the future in an historic context. If current events strike us as all surprise and shock, it is because we cannot see these events in a meaningful framework." Again, however, mere fact accumulation is not, or should not be, the aim of the study of history.

Though some argue otherwise, an engineer can well use an understanding of political, economic and social factors in his environment. Whether in design work, plant supervision, sales, or product or company planning, he should try to comprehend the influence of past and current world events on people's attitudes. With such comprehension comes better judgment in selecting the factors most important for his company and his industry.

To form this historical perspective in the engineering student, a college history sequence might require analyses of the forces that have shaped our history, and are still doing so—for example, nationalism, religion, economics. Projecting these analyses to current affairs, the student would then see the present as a stage in the flow of man's history. After reaching such understanding, he then has a base to extrapolate to the future.

This is the real, practical purpose of teaching history to chemical engineers. Its effect on foresight, tolerance and understanding results in them being better managers, better professional men and more-responsible citizens.

An Argument for Study in Depth

English and American literature, often taught as a survey course, can be much more. It is a means of acquiring knowledge of human behavior, a way of learning verbal expression. Interrelated with historical studies, it provides an intimate view of other lives and times.

Human behavior is frequently studied in courses on psychology and sociology, but can the lust for power, and its resultant corrosion of the soul, be expressed more eloquently than in Macbeth? Can the conditions of the industrial revolution be more clearly felt than by reading Dickens, or moral fervor be more readily appreciated than by reading Hawthorne? A judicious selection of literature can furnish an insight into psychology, history and philosophy that nowhere else is provided more dynamically.

But besides these values, literature courses offer to the chemical engineer an exposure to various writing styles in his mother tongue. Good writing can best be taught in the company of the great English-language writers. This is not to argue for the standard composition course required of engineering students. It is erroneous, I believe, to award humanities credits for acquiring what should be an already-learned technical skill.

To promote this approach to literature requires less width, more depth in its teaching. Yet, how can such a study in depth be undertaken by the non-arts major, specifically, by the engineer.

Take an example: Many three-credit hour courses in Shakespeare require the reading of perhaps 15 plays. Even an English major, reading about one play per week, can barely remember characters and plots. The student will appreciate little of the poetry, and know practically nothing of the Elizabethan world view, in such a course.

Far better is the course that concentrates on, say, "King Lear," "Hamlet," "Macbeth," and "Othello," and that requires skimming, and analysis of only the pertinent passages, of other plays. The usual exercises —examining Shakespeare's debt to Hollingshead, memorizing famous passages, identifying characters by their speeches—should be omitted. After all, college studies are to educate the student, not train him for a TV quiz show.

Poetry, imagery, style and philosophy of the Bard can be appreciated if active discussions and penetrating analyses are done in a seminar course. This demands attributes and attitudes that a student with scientific bent is likely to have, likely to use with pleasure. As well as to acquaint the engineer with a small part of his literary heritage, the spurring on of the inquiring mind is a major purpose of such in-depth treatment.

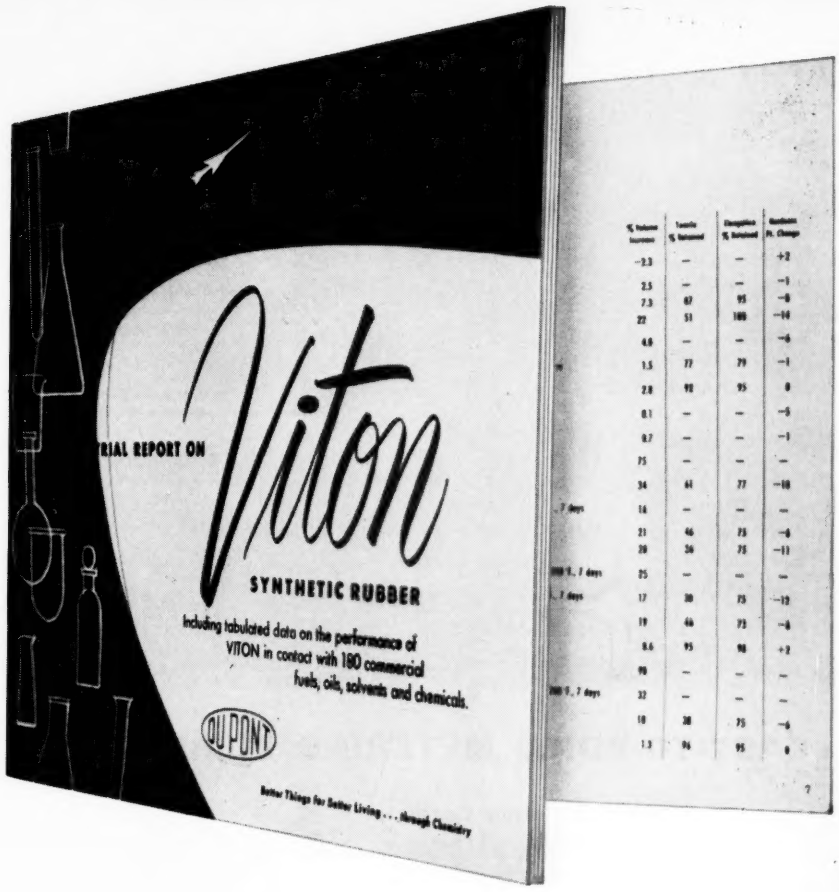
Philosophy, history and literature are the most important branches of the humanities for the chemical engineer. A study of the fine arts seems less practical, but the general benefits of it are important, too. There is no doubt that art is not only an expression of emotions that arise from social, psychological and political experiences, but also a powerful molding influence on the lives of non-artists.

A more-direct, practical use for the chemical engineer is the effect of a study of the fine arts on his taste, say, in product design and advertising.

Putting the Curriculum to Work

A two-decade-old American Society for Engineering Education report recommends that 20% of the credits required for graduation as an engineer be devoted to the humanities and social sciences. If these courses are well-conceived (perhaps, too, taught in a five-year course), they should be adequate for engineering students who have reasonably good general high-school background.

Because engineering-course subject matter is so large, and constantly expanding, the student's education must be one directed toward developing the attitudes and skills basic to his chosen career. But at the same time, his education is for his potential as a competent professional man, a manager and a responsible citizen. A penetrating, integrated humanities programs, such as I have suggested, can offer intellectual challenge and practical importance by its contribution to these aims.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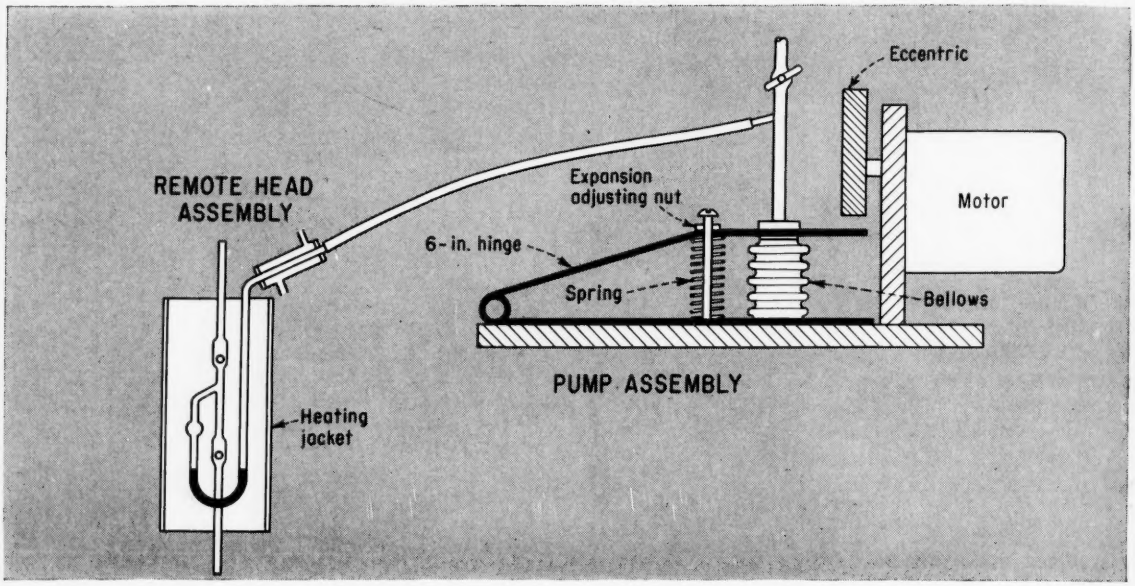

EASY-TO-BUILD METERING PUMP CARRIES CORROSIVES

Winner of the July Contest*

G. MACBETH and C. H. RADDLE

Dow Chemical Co., Pittsburg, Calif.

While the use of a liquid piston to pump corrosive liquids is not new in itself, the metering pump shown in the illustration has the advantages of being inexpensive to build, easy to incorporate into glass equipment, and simple to heat for handling high-melting solids.

The particular continuous-duty application in which this pump proved so successful was the metering of molten compounds from one unit of a miniplant to the next processing step.

The check valve and piston assembly is made entirely of glass so that the only other material contacted by the fluid being pumped is that which forms the liquid seal. In our particular case, we used mercury as the seal.

The entire valve and loop assembly was housed in an electrically heated jacket, with a thermocouple inserted to assure maintenance of a suitable temperature. An air-cooled jacket on the pump side of the housing prevented overheating the Saran connecting tubing.

Arrangement of the valves and connecting loop is such that the unit readily purges itself of air on the valve side of the loop. The *Y* and valve arrangement shown above the bellows permits ready addition of the hydraulic fluid (ethylene glycol), and elimination of air from the pumping side of the loop.

The pumping unit consists of a slow-speed fractional horsepower motor driving an eccentric, which in turn activates a bellows by means of the spring-loaded hinge shown. Adjustment of the pumping rate can be made during operation by controlling the amount of expansion permitted the bellows.

A 1-in.-dia. bellows (a spare part for a d/p cell) and a ¼-in. offset of the eccentric gave us a 1 liter/hr. pumping rate at midcapacity with a 25-rpm. motor.

Pump capacity is a function of a number of variables under the control of the builder. These are the diameter of the bellows, the degree of compression possible (as set by the eccentric cam) and the motor speed. With these variables at hand and the possible refinement of a variable-speed motor, this metering pump has a wide range of applications.

COMING OCTOBER 30

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Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant Notebook Editor, *Chemical Engineering*, 330 W. 42 St., New York 36.

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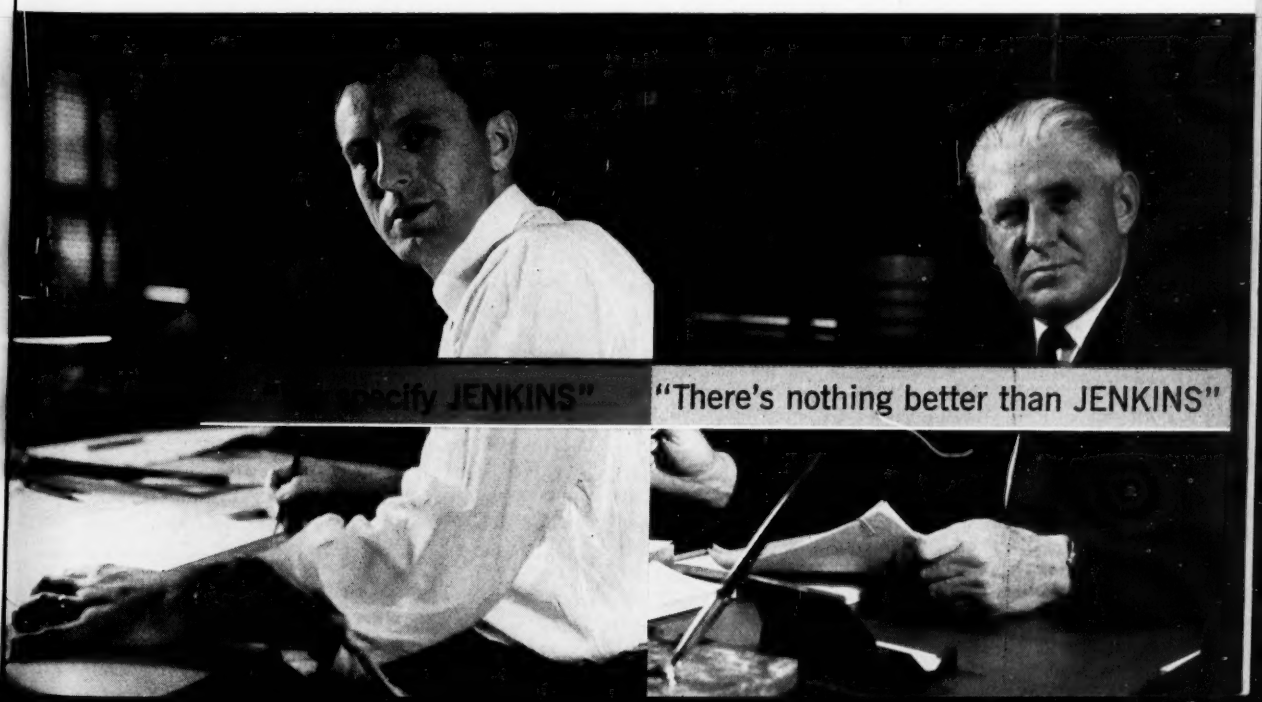

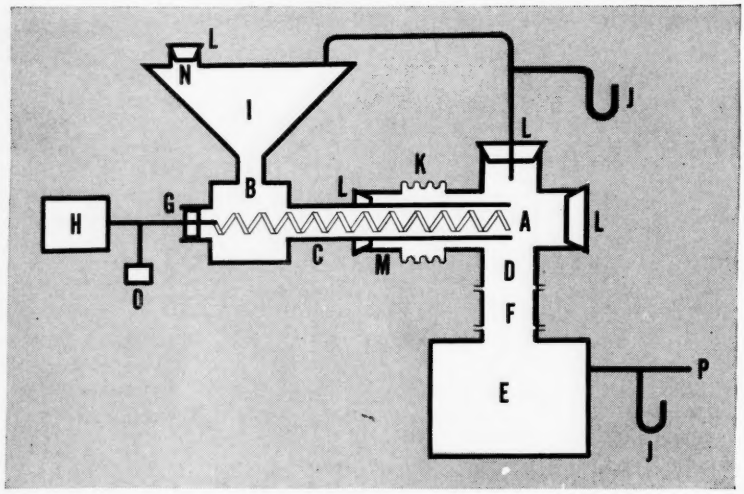

A—Rotating screw
B—Feed trough
C—Barrel
D—Cross
E—Reactor
F—Connecting pipe
G—Garlock seal
H—Graham drive
I—Feed hopper
J—Vacuum gage
K—Expansion bellows
L—Rubber stopper
M—Metal tube
N—Charging port
O—Tachometer
P—Vacuum source

VIBRATING SCREW PUSHES SOLIDS INTO VACUUM REACTOR SYSTEM

A. N. JOHNSON, F. P. COOPER and J. A. DAVISON
Research and Development Dept., U. S. Rubber Co.

One of our laboratory programs involved treatment of various materials with heat, for a brief contact time at reduced pressures of about 1 to 100 mm.

With liquid and gaseous starting materials, it was easy to maintain uniform feed rates by conventional means. With solid products, however, it was harder to do this. The methods available for solving this problem were: (a) liquid melt, (b) sublimation, (c) distillation, (d) solution feed, (e) solid feed.

The first four of these methods had certain limitations in our application and we found method (e) to be the most desirable. We believe that this technique could be applied to a variety of processes involving feed of solid products into reactors at reduced pressure.

The equipment we used to accomplish the solid feed was a stainless steel Vibra Screw Solid Feeder. These units are available in a variety of sizes, and we used standard ¼-in. and ½-in. models, modified with the cooperation of the manufacturer for vacuum work.

The machine consists of a rotating screw *A*, which picks up the solid in a feed trough *B*. The solid is conveyed through a barrel *C*, which terminates in an auxiliary cross *D* attached to the top of the vacuum reactor *E* through a connecting pipe *F*. The other end of the screw passes through a Garlock seal *G* and is connected to a variable-speed Graham drive *H*.

Delivery rate is a function of the screw speed. Adjustment of the speed permits nearly 100 to 1 controlled variation of feed rate.

A hopper *I* holds the solid for the feed trough and is subjected to controlled vibration. The top of the hopper is connected to the cross by a pressure-equalizing line, which is also attached to a vacuum gage *J*. (We prefer a glass cross for visual observation of flow rate, and we use an expansion bellows *K* to absorb vibration.) Rubber stoppers *L* were used at the cross, and for connecting the feed barrel to a metal tube *M* attached to the bellows.

We found it desirable to heat the vertical section of the pipe *F* connecting the cross to the reactor. This prevented the product from melting and resolidifying before reaching the reactor.

We found that this feeder produced reasonably uniform delivery rates of free-flowing powder or granular solids. These rates were slightly lower for any given setting as vacuum was increased.

We used feed screened through a 30-mesh sieve for powders, and an 8-mesh sieve for crystalline products of larger particle size. The material was added to the hopper through a charging port *N*. We weighed the products before use, in order to make material balances.

We also installed a tachometer *O* to facilitate calculations of feed rates in cases where we varied settings during the run.

In first applying vacuum *P* to the system, we found it wise to reduce the pressure gradually to about 150 mm. If this was not done, fluidized solid would sometimes short-circuit the screw on initial application of high vacuum.

Test Your CEQ

ROBERT LEMLICH

If, in the previous problem (*Chem. Eng.*, Sept. 4, 1961, p. 152), the transfer of liquid back and forth is repeated 10 more times, how will the final concentration (by volume) of *A* in the second vat compare with that of *B* in the first vat? *Answer on page 126*

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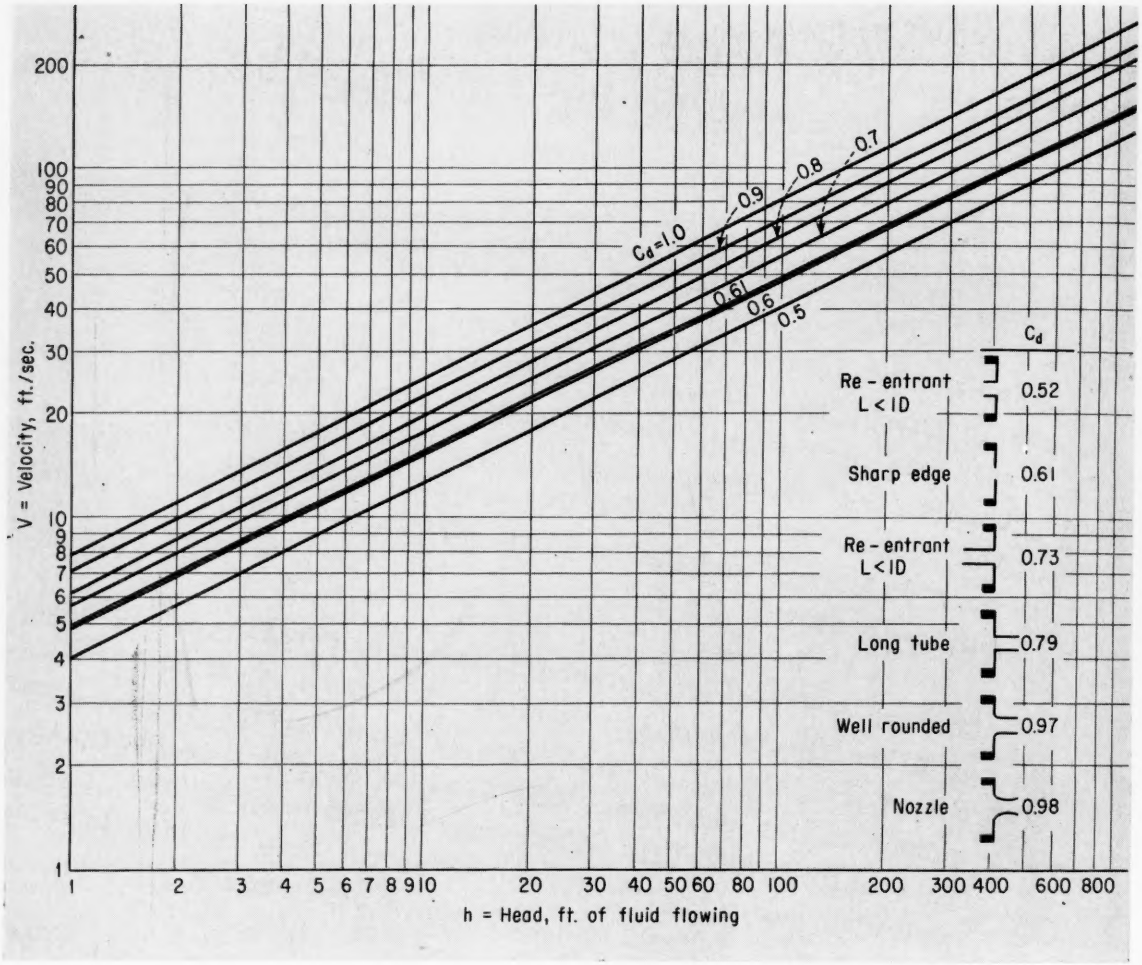
VELOCITY OF FLUID FROM ORIFICES

EDWARD J. GIBBONS
Colgate-Palmolive Co., Jersey City, N. J.



This third design chart gives the velocity of fluid from an orifice, by the equation:

$$V = C_d\sqrt{2gh}$$

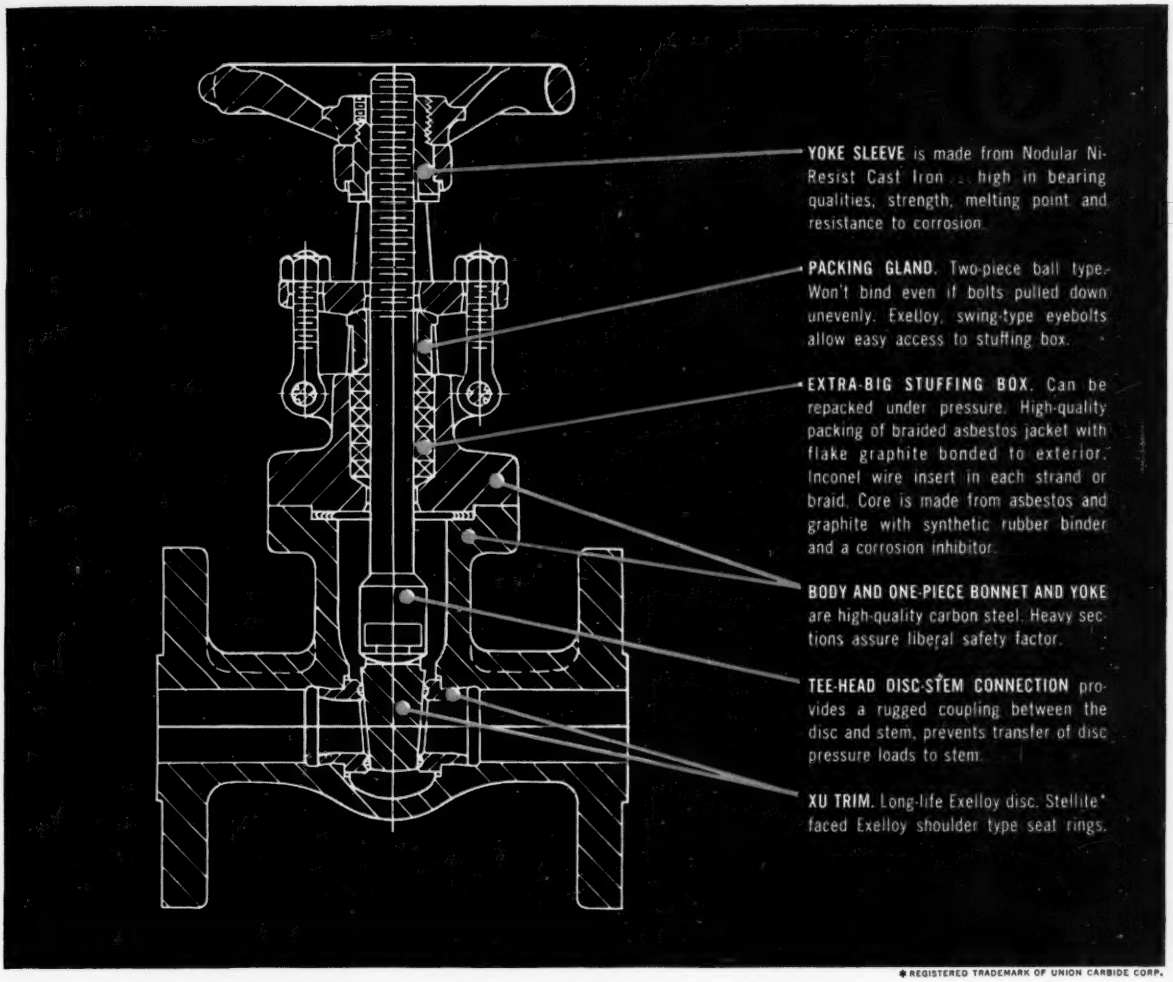
where V is the velocity, ft./sec., actual; C_d is the orifice coefficient of discharge; g is 32.2 ft./sec./sec.; h is the pressure head, ft., of the fluid flowing, and is equal to the pressure, psi., times 2.31 times the specific gravity.

Answer to Test Your CEQ

Regardless of the number of transfers we make back and forth, and regardless of the order or size of the transfers, the net A removed from the first vat must appear in the second vat. Similarly, the net B removed from the second vat must appear in the first.

Now, in the present problem (as well as in the previous), one effect of the transfers is to make the final volume in each vat equal to the original volume in each. This means that the net volume of A transferred to the second vat "displaces" an equal volume of B, which is transferred to the first vat.

Thus, the final volume fraction of A in the second vat will still equal the final volume fraction of B in the first vat.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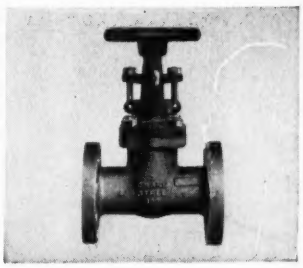

AT THE HEART OF HOME AND INDUSTRY

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No. 57: Pump and Compressor Costs

Handy charts give accurate purchase costs for three important types of process equipment: centrifugal pumps, gear pumps, centrifugal compressors.

It would be a very difficult task to present cost data for all the different types of pumps used in the chemical process industries.

This may be one reason why the cost literature does not contain a great deal of information on pump costs.

However, there are two pumps that are used extensively in chemical plants. And it is possible to plot costs for these pumps.

Fig. 1 shows data for horizontal, single-stage, end-suction, pedestal-mounted centrifugal pumps. Costs include pump, base plate, coupling and mechanical seal. Materials of construction are cast iron or cast iron, bronze fitted. The table can be applied when there is a departure from standard materials.

Costs are based on first quarter, 1960 data.

* Based on material prepared by the Engineering Dept., E. I. du Pont de Nemours & Co., for the forthcoming fourth edition of Perry's "Chemical Engineers' Handbook."

Continued on page 130

Purchase costs for general-purpose centrifugal pumps—Fig. 1

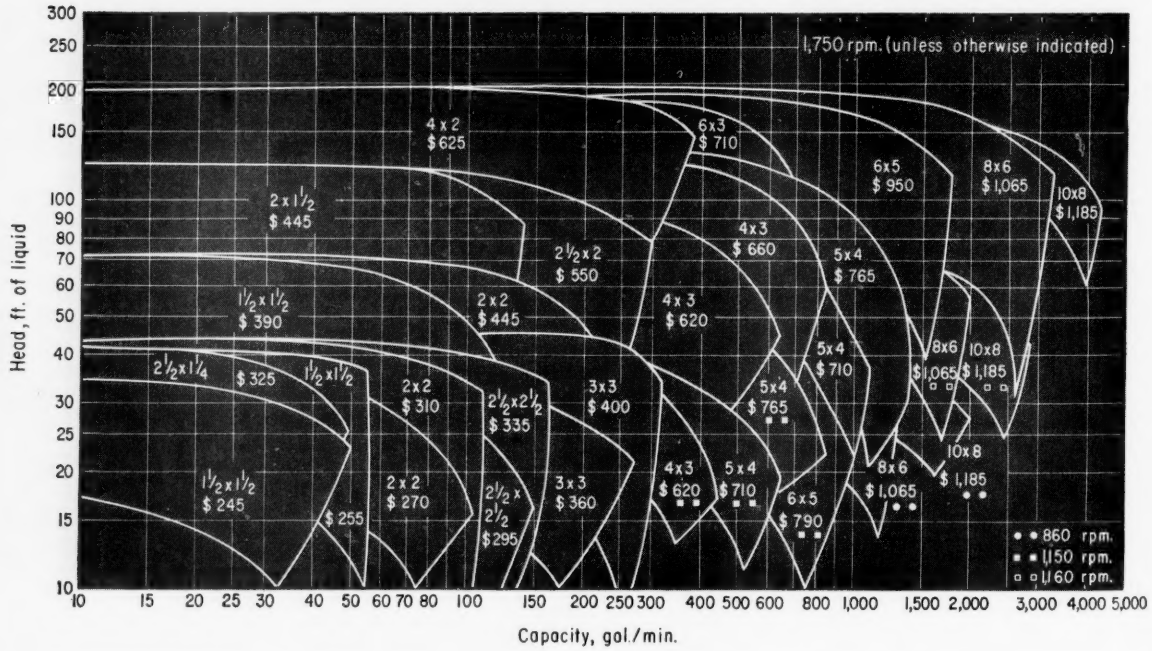

Chart is based on cast iron or cast iron, bronze fitted. For other materials of construction, multiply chart values by:

Cast iron, 316 stainless fitted	1.34	316 stainless	1.85
Bronze	1.44	Carpenter 20	1.93
Ductile iron	1.44	Worthite	2.00
Cast steel	1.72	Hastelloy C	3.00

Adjust chart costs by the following:

	Add Dollars
316 stainless shaft	50 to 100
Trap and separator for self-priming pumps	300 to 500
Stainless drip pan	80 to 150
Ferroxyl test	60 to 100
Halide test	40 to 50

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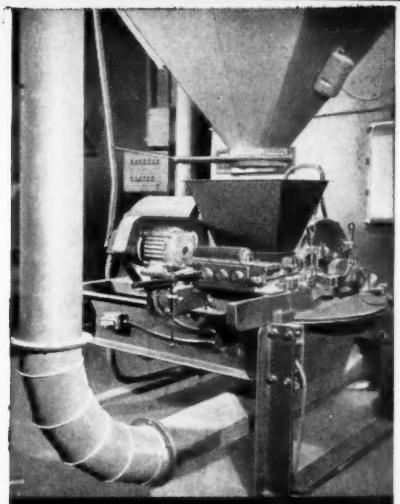

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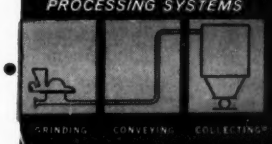
PROCESSING SYSTEMS



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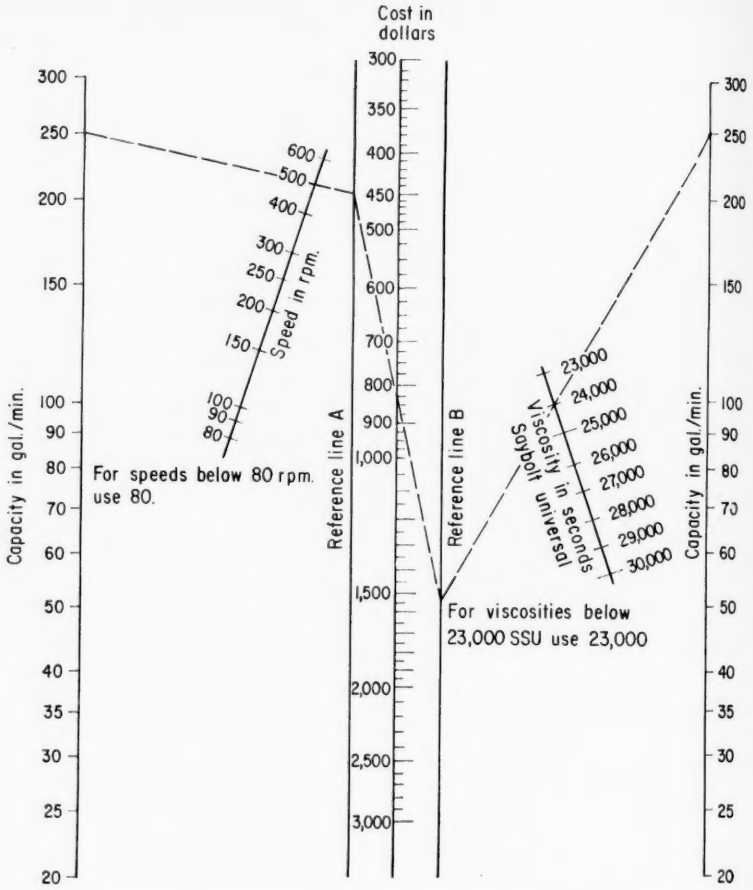
Nomograph gives gear-pump costs—Fig. 2

Gear pumps are widely used in chemical operations. Fig. 2 presents purchase costs for gear pumps of conventional design. Data are based on cost of pump, base plate and coupling, for cast-iron or steel construction. For other materials, multiply values from the nomograph by:

Bronze	1.40
316 stainless	1.50

To use the nomograph, (1) pass a line through the capacity scale (on the left) and speed scale, then mark intersection on Reference line A; (2) pass a line through capacity scale (on the right) and viscosity scale, then mark intersection on Reference line B; (3) connect points on Reference lines A and B and read answer on center scale.

Costs are based on third quarter, 1958 data.


Cost in dollars
Capacity in gal./min.
Speed in rpm.
For speeds below 80 rpm. use 80.
Reference line A
Reference line B
Viscosity in seconds Saybolt universal
For viscosities below 23,000 SSU use 23,000
Capacity in gal./min.

In general, compressor costs are not difficult to correlate. For reciprocating machines, costs can be approximated by the following:

Purchase cost in dollars = 4,100 + 53 $hp._{is}$, where $hp._{is}$ is the isentropic horsepower. This equation applies to cast-iron construction, and cost includes compressor, base plate, and drive motor. Costs are fourth quarter, 1960.

For centrifugal air compressors, Fig. 3 shows the relationship between purchase cost and $hp._{is}$.

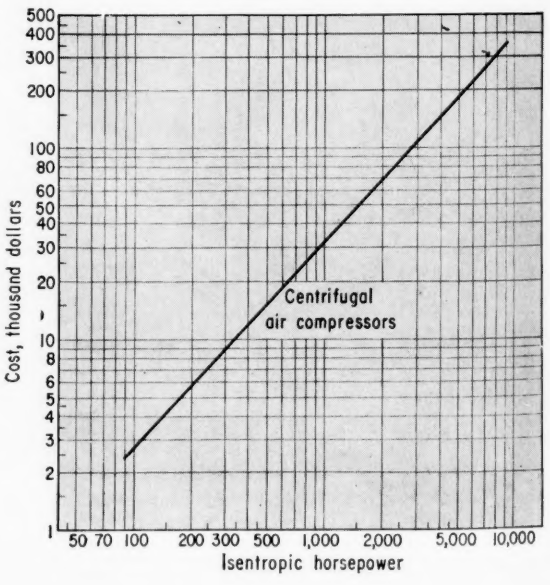
The correlation does not apply to gases having molecular weights different from air. Lower molecular weight gases require a larger machine for the same horsepower input, while the reverse is true for higher molecular weights. It is difficult to establish a correlation for effect of molecular weight on centrifugal-compressor costs, since handling of process gases often calls for special materials of construction and elaborate sealing systems.

Centrifugal costs are based on cast iron stationary members with a forged-steel rotating element, base plate and coupling. Cost does not include drive.

Data are based on first-quarter 1961.

For isentropic-horsepower calculations, see Perry's "Chemical Engineers' Handbook," 3rd ed., p. 1,440.

Centrifugal air compressor purchase costs—Fig. 3



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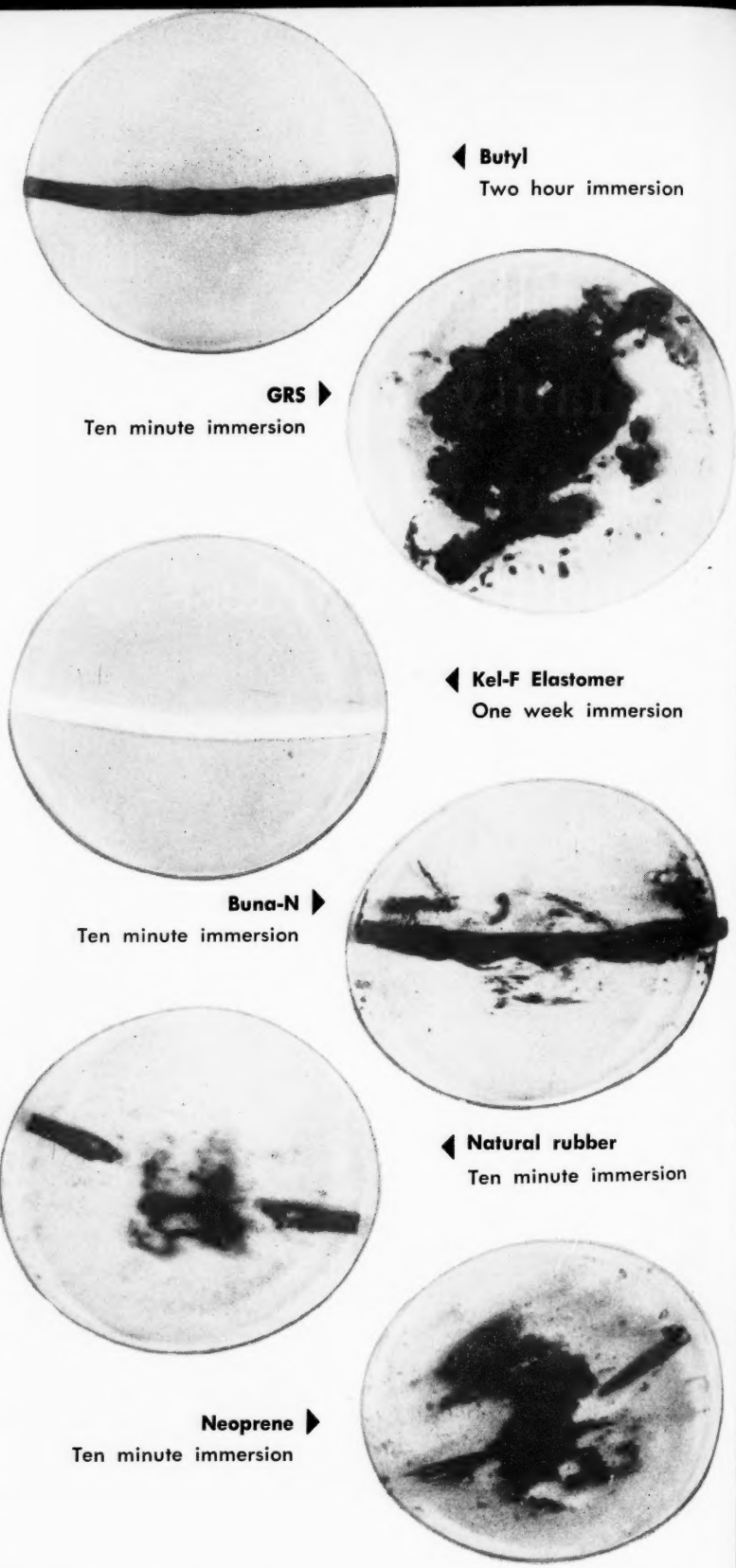
Specialty Rubbers for Special Uses-II

Information is presented on the chemical resistances of the specialty elastomers, that were discussed in Part I of this two-part article.



Chemical resistance to red fuming nitric acid

A table of chemical resistances of the various specialty rubbers discussed in Part I of these two articles (Chem. Eng., Sept. 18, p. 204) is presented on the following page. These data were provided by the manufacturers of the various elastomers.

It should be emphasized again that a table of this sort must be used only as a guide for selecting materials for further testing. The conditions of the test method are

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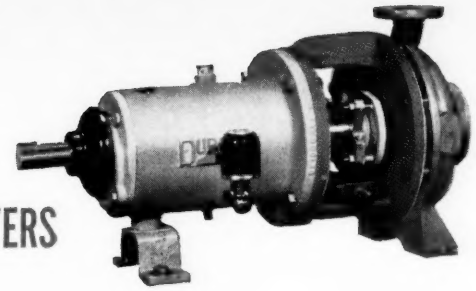
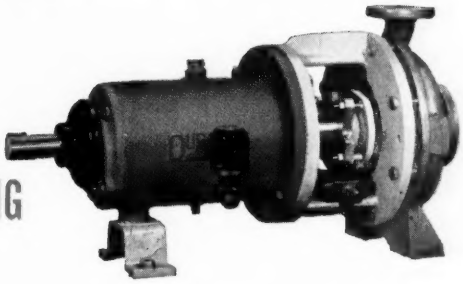
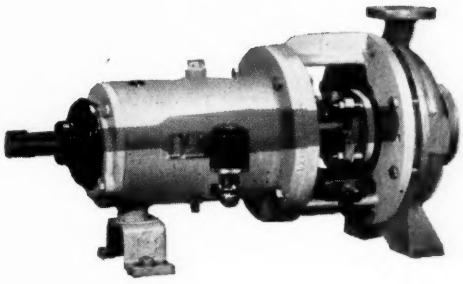


DURCO ADAPTERS



ENABLE
ONE BEARING HOUSING



AND ONE SHAFT

TO ACCOMMODATE 10 DURCOPUMPS
WITH CAPACITIES TO 750 GPM & HEADS TO 345 FT.

DURCO INTERCHANGEABLE PARTS CUT PUMP INVENTORY COSTS

Since bearings, bearing housings, shafts, impellers and supplementary parts on all Durcopumps are interchangeable over a wide range of sizes, it takes only a small inventory of spare parts and seals to maintain a complete range of pumps in your plant.

Also, Series H Durcopump parts in 14 standard alloys are interchangeable. Even though your corrosive conditions require several Durco alloys you can maintain pumps from a small general inventory. Only casings, impellers and cover plates may be required on special inventory.

Durcopumps with interchangeable parts are also available in sizes to 10″ x 8″ with capacities to 4250 GPM.

Your local Durco Engineer can give you a full appraisal of your maintenance cost savings with Durcopumps.

THE DURIRON COMPANY, INC., *Dayton, Ohio*
Serves the process industries

DURCO

almost never the same as the conditions under which the materials will be used. The most widely used test (ASTM D471-57T) is an immersion test. But complete immersion under laboratory conditions may not even approximate the actual service environment where the rubber parts may be only partially immersed, or subjected to the action of several different chemicals during various process stages.

The ASTM D471-57T procedure contains this warning, "Owing to the wide variations often present in service conditions, no direct correlation between this accelerated test and service performance may be given or implied. However, the method yields comparative data on which to base judgment as to service quality and is especially useful in research and development work."

▶ **Swelling**—Generally, the most obvious effect that solvents and oils have on these elastomers is swelling. Frequently, swelling may be the limiting factor determining whether the rubber is useful or not. There are cases, however, where a small amount of swelling may even be desirable. For example, O-rings often function better if they swell slightly in the liquid that they seal. Of course, if they swell too much, they may be forced out of position and become completely ineffective.

▶ **Temperature**—In general, chemical and solvent resistance decrease with increasing temperatures. A solvent that has little effect at room temperature may produce a marked swell at 400 F. Solvent effects are also dependent on duration of exposure time. Elastomers may recover most of their original properties if they are permitted to dry after exposure to a volatile solvent.

▶ **Chemical Resistance**—The table at the right shows the degree of swell suffered by four specialty rubbers. This is the most important property in the case of solvents and oils. Corrosive chemicals may also have other effects such as a change in hardness.

▶ **About the Table**—Data listed in the table are from the manufacturer's literature or supplied by him. Only a selected list of chemicals is presented in the table—considerably more data are available from

Resistance of specialty elastomers to various solvents and corrosive chemicals

Chemical	Viton			Fluorel 2141			Kel-F Elastomer				Silicone Rubber				Hypalon		
	°F.	Days	% Swell	°F.	Days	% Swell	Cure	°F.	Days	% Swell	Silastic Stock[1]	°F.	Days	% Swell	°F.[2]	Rating[3]
Acetic acid, glacial	75	7	62	77	7	180					50	77	7	3	R.T.[2]	B
Acetone	75	7	271	77	7	374					80	77	7	13	R.T.	B
Aniline	75	7	3	77	7	5	Peroxide	77	27	5	LS-53	77	7	4		
ASTM oil No. 1	300	7	0.2				Peroxide	77	27	0	50	300	7	8		
ASTM oil No. 3	350	7	2.5	300	7	3	Peroxide	77	27	1	LS-53	300	7	6		
Carbon tetrachloride	75	7	1.3	77	7	2	Polyamine	77	27	16	LS-53	77	7	21	R.T.	C
Chlorine gas	212	5	Nil				Peroxide	77	7	2					R.T.	B
Cyclohexane	75	7	4	77	7	350	Peroxide	77	1	700	LS-53	77	2	16	R.T.	C
Ethyl alcohol	75	28	6	77	7	2	Peroxide	77	27	6	80	77	7	2	200	A
Ethyl acetate	75	1	425	77	7	375									R.T.	C
Ethylene dichloride	75	3	10.5												R.T.	C
Ethylene glycol	212	14	2.1				Peroxide	77	27	1	LS-53	77	7	Nil	200	A
Freon 12	75	28	21								LS-53	77	7	33	R.T.	A
Hydrochloric acid, 37%	158	7	3.2	77	7	32	Peroxide	77	27	16	80	77	7	−2		
Methylene chloride	100	28	29	77	7	30									R.T.	C
Nitric acid, 60%	75	7	4.4								LS-53	77	7	1	R.T.	B
Nitric acid, red fuming	75	7	22.9	77	7	64	Peroxide	77	27	24						
Oleum, 20%	75	7	2	77	7	12	Peroxide	77	27	1					R.T.	C
Phosphoric acid, 60%	212	7	0.5													
Sodium hydroxide, 50%	75	7	2.1	77	7	0					50	77	7	−1	158	A
Steam	400	3	4.8				Peroxide	400	7	22						
Sulfuric acid, 60%	250	7	5.2												158	A
Toluene	75	3	8				Peroxide	77	27	55					R.T.	C
Trichloroethylene	153	23	14.7	77	7	6	Peroxide	77	27	53	LS-53	120	5	21	R.T.	C

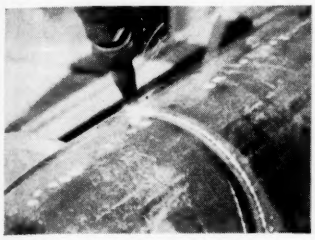
[1] See text under heading "About the Table" for an explanation. [2] "R.T." = room temperature. [3] A = little or no adverse effect, B = minor to moderate effect, C = severe effect.

THE SURPRISING ECONOMICS OF BONDSTRAND®

. . . the pipe designed for corrosive chemicals

A 20′ length of 6″ schedule 40 carbon steel pipe weighs 398 lbs. Crane required for lifting.

A 20′ length of 6″ Bondstrand pipe weighs only 60 pounds. One man can lift and carry.



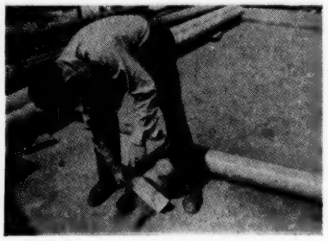
Cutting steel pipe takes four (or more) times longer than Bondstrand.

Bondstrand is cut with ordinary hacksaw. Preheating not required.

Two men required to bevel, clean, position, center and level a 90° elbow before welding.

Only one man required to apply adhesive and position a 90° Bondstrand elbow. It aligns itself.

Welder and helper required to tack weld, check alignment, make stringer weld and grind, make flush weld and grind again, make cover weld, grind and wire brush.



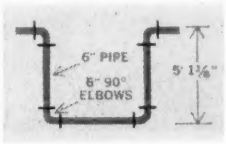
One man with a hammer and a two-by-four makes the Bondstrand Quick-Lock joint in a matter of seconds. Important: **Bondstrand pipe may be handled immediately; no waiting for adhesive to cure.**

IT TOOK 65 MINUTES TO WELD ONE ELBOW TO STEEL PIPE. ONE MAN MADE THE SAME ASSEMBLY WITH BONDSTRAND IN ONLY 10 MINUTES!

BONDSTRAND, the fiber glass reinforced epoxy pipe, handles nearly every corrosive solution—acids, salts, alkalies—used in industry today. It will withstand pressures up to 550 psi and temperatures up to 300°F. So will the complete line of BONDSTRAND fittings, 2″ through 12″.

The smooth, abrasion-resistant inner surface permanently retains its excellent flow characteristics (Hazen-Williams formula C=150) and thus often permits use of one-size-smaller diameter pipe. BONDSTRAND is only one-eighth the weight of steel and because it resists exterior as well as interior corrosion it does not require continual maintenance painting.

BONDSTRAND versatility is unmatched by any other pipe—metallic, thermoplastic, glass or lined. What does this superiority cost? Less than you may suspect. Here is how BONDSTRAND compares with carbon steel in this simple pipe layout:



TOTAL COST OF MATERIAL AND LABOR

Schedule 40 **Carbon Steel** Pipe With Welding Elbows	**$225.63**
Series 4000 **Bondstrand** Pipe With Bondstrand Elbows	**$287.40**

Figures shown are from a strict time-and-cost study conducted by one of Southern California's leading independent piping and engineering firms.

This means that in this layout you get all the advantages of BONDSTRAND for only 21.7% more than ordinary carbon steel pipe. (In complex process piping, BONDSTRAND can actually cost less.) In Schedule 40 stainless steel, which approximates BONDSTRAND's chemical resistance, the layout would cost $1,287.50—*348% more than* BONDSTRAND!

To evaluate the superiority of BONDSTRAND *pipe for your specific requirements, write for complete technical data.*

Amercoat® CORPORATION 136

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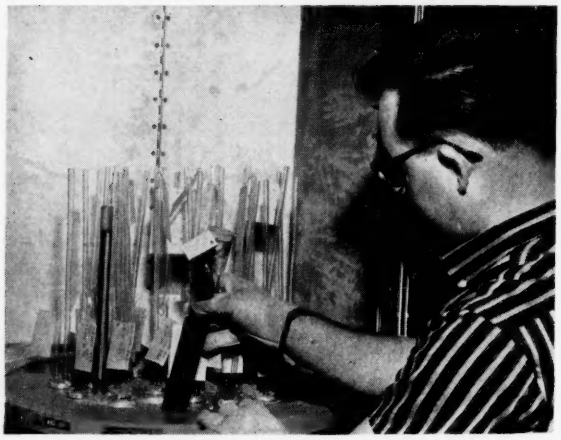
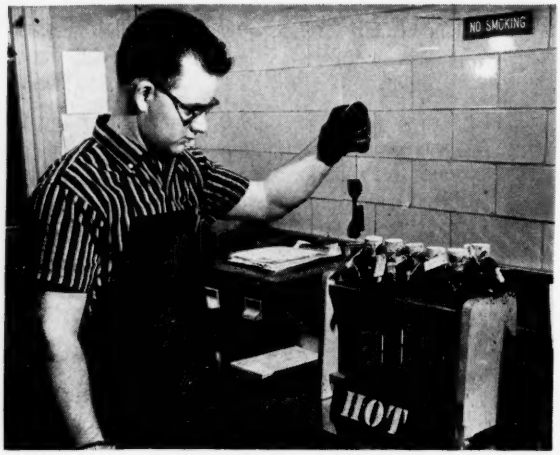
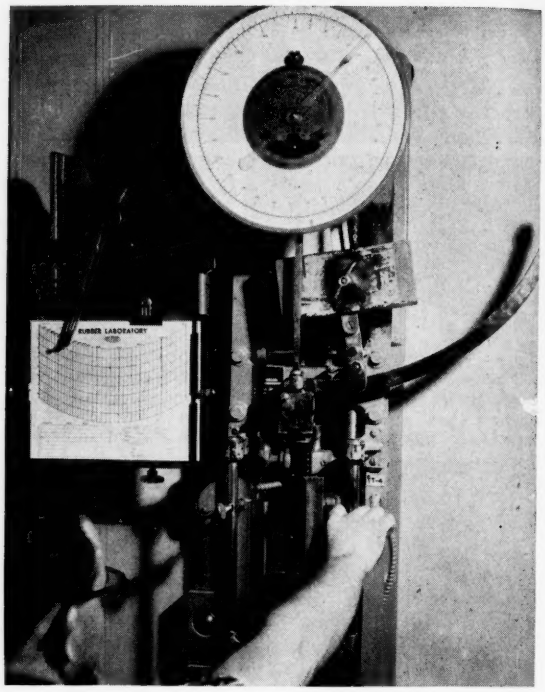
921 Pitner Ave., Evanston, Ill. | 360 Carnegie Ave., Kenilworth, N. J. | 111 Colgate Ave., Buffalo, N. Y. | 2404 Dennis St., Jacksonville, Fla. | 6530 Supply Row, Houston, Tex.







Viton sample, immersed in solvent, is placed in a controlled temperature bath. (Upper left.)

Sample is removed after timed exposure to solvent and examined for damage. (At left.)

Scott tester measures retention of samples' original physical properties. (Above.)

Kel-F elastomer in red fuming nitric acid

Formulation	
Kel-F elastomer	100
Zinc oxide	10
Dyphos	10
Benzoyl peroxide	1.5
Cure	
Press, hr./°F.	½/230
Oven, hr./°F.	16/300
Properties	
Stress (300% elongation), psi.	800
Tensile strength, psi	2,200
Elongation, %	450
Hardness, Shore A	55
After 3 Days in Fuming HNO_3, 77 F.	
Stress (300% elongation), psi.	400
Tensile strength, psi	700
Elongation, %	
Volume swell, %	25
Hardness, Shore A	44
Tensile strength retention, %	32

the individual manufacturers. Unfortunately, the test data are not directly comparable. Different laboratories tend to run the tests at various temperatures, for differing periods. Most of the tests were run using ASTM D471-57T.

In the case of silicones, the data presented are from Dow Corning. Since the silicone rubbers made by various manufacturers vary so much, it seemed reasonable to present data from one source. Dow Corning was selected because it replied to CHEMICAL ENGINEERING'S request for information on chemical resistance with a more complete listing of data than did the other silicone rubber manufacturers. Silastic types 50 and 80 (referred to in the table) are regular silicone rubber stocks and similar materials are available from the other silicone rubber manufacturers. Silastic LS-53 is a fluorosilicone rubber, which is a specialty of Dow Corning.

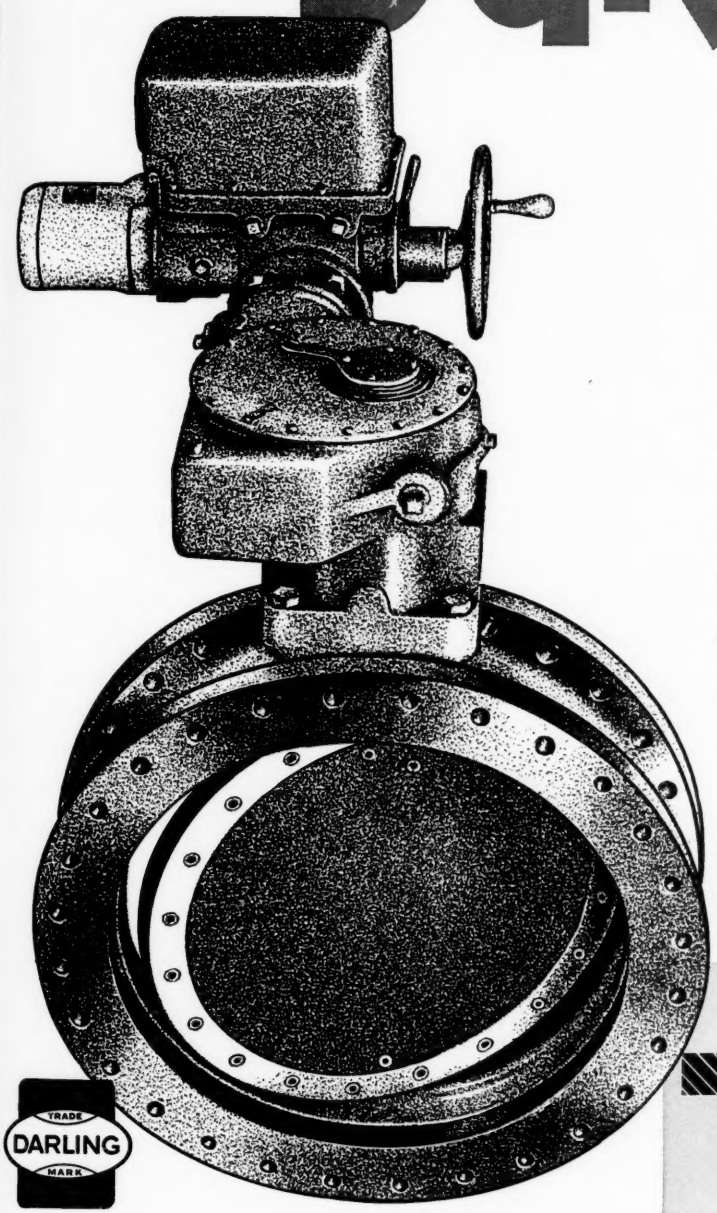
In general, when several formulations are available, the one most resistant to the chemical in question is listed. For example, the Viton shown under "red fuming nitric acid" is a special acid-resistant type.

In the case of Hypalon, actual test data were not available. The "effect" ratings are those supplied by Du Pont, and are based on retention of all physical properties (e.g., swelling, elongation and hardness) rather than degree of swelling alone.

Less resistant than the other rubbers discussed, Hypalon deserves attention because of its relatively low price.

YOU CAN DEPEND ON

Darling



GATE • BUTTERFLY • CHECK • SPECIAL VALVES • FIRE HYDRANTS

drop-tight shutoff
maximum seat life
easy operation

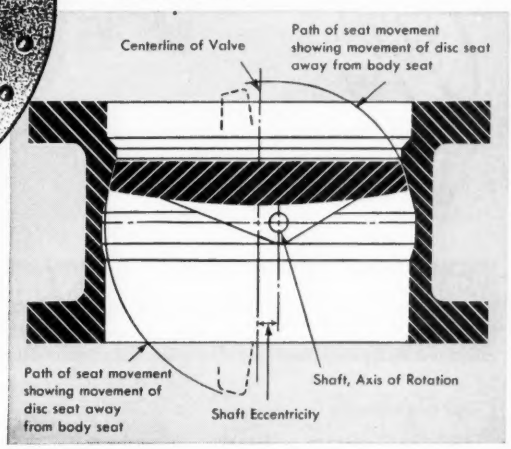
Darling-Pelton Butterfly Valves have a continuous 360° rubber sealing ring, uninterrupted by the valve shaft, that makes complete drop-tight shutoff possible. The valve disc, swinging on an axis eccentric to the valve centerline, is exceptionally easy to operate. It lifts away from the body seat on opening to eliminate any abrasion or distortion. The rubber seat can be replaced quickly without dismantling the valve. *You can depend on* Darling-Pelton Butterfly Valves for safety, long service, superior performance.

Write, wire or phone for your copy of Bulletin 5904 giving complete information on these butterfly valves made to A.W.W.A. Specifications.

DARLING VALVE & MANUFACTURING CO.
Williamsport 3, Pa.

The Canada Valve & Hydrant Co., Ltd., Brantford 7, Ontario, Canada
Vannes Darling-France, 23 rue du Commandant Mouchotte, St. Mandé, France

Exaggerated diagram showing eccentricity of valve shaft in relation to valve axis and how the disc, upon opening, is lifted from the body seat throughout its entire circumference.


Centerline of Valve
Path of seat movement showing movement of disc seat away from body seat
Path of seat movement showing movement of disc seat away from body seat
Shaft, Axis of Rotation
Shaft Eccentricity

Continued from page 56

will be 300 tons/day of ammonia, nitric acid, nitrate solution, ammonium nitrate, urea and nitrogen solutions. Anticipated on-stream date hasn't been divulged.

Pittsburgh Metallurgical Co. has begun a $3-million expansion of its Niagara Falls, N. Y., facility. Scheduled for completion in about seven months, program calls for construction of two new electric furnaces to produce ferroalloys used by the steel industry.

Celanese Polymer Co., a division of Celanese Corp. of America, plans a Jan. 1, 1962, on-stream date for its Celcon polyacetal plant at Bishop, Tex. Capacity will be 20 million lb./yr; company expects to be producing ten times that amount by 1970. Product will be about ½-in. in dia., to come packed in 50-lb. bags.

Union Carbide Chemicals Co. has started up its Brownsville, Tex., facility. Current output is acetic acid, but acetic anhydride and methyl ethyl ketone are also scheduled for production. And the firm is studying the possibility of producing additional chemicals there. Neither cost nor capacity was disclosed, possibly because "several" new processes are being used.

Cerro Corp. and **Bridgeport Brass Co.** are jointly studying the feasibility of a 56,000-ton/yr., primary-aluminum reduction plant for the 1,030-acre site in Wauna, Ore., which Cerro optioned earlier this summer (*Chem. Eng.*, Aug. 21, p. 152). Cerro has signed a 20-year contract with the Bonneville Power Administration for 90,000 kw. of electrical power, calling for delivery no later than Sept. 1, 1963.

International Salt Co. has made a test shipment of rock salt from its Cleveland mine. When in full production, up to 1.5 million tons/yr. of salt is to be removed from the mine, which taps a 5,100-acre area under Lake Erie. Two shafts, sunk

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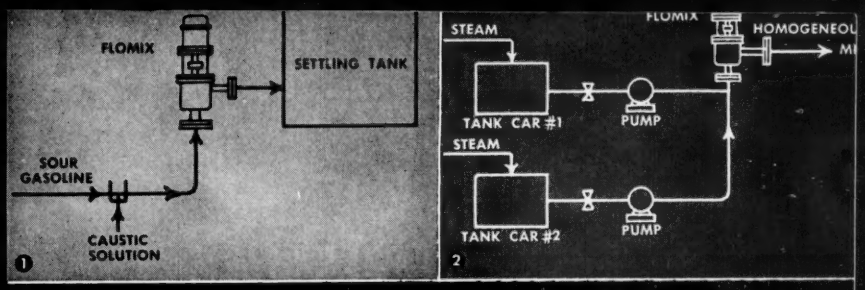
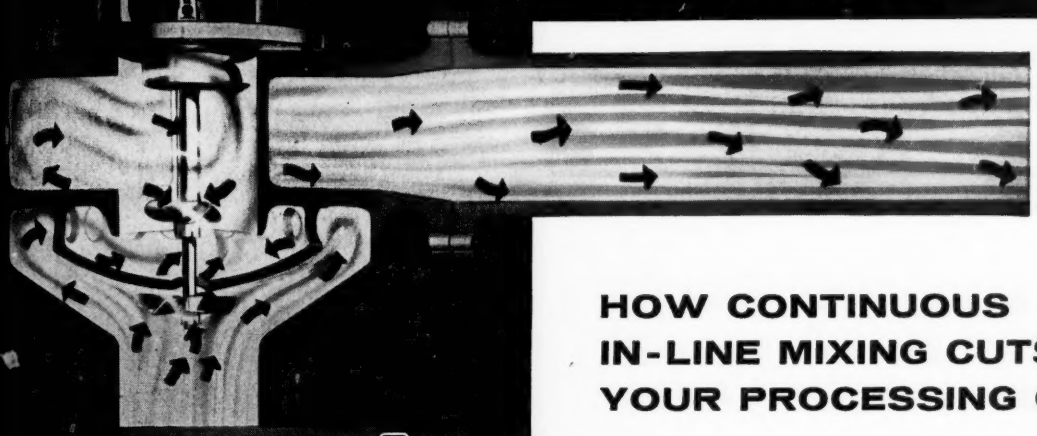
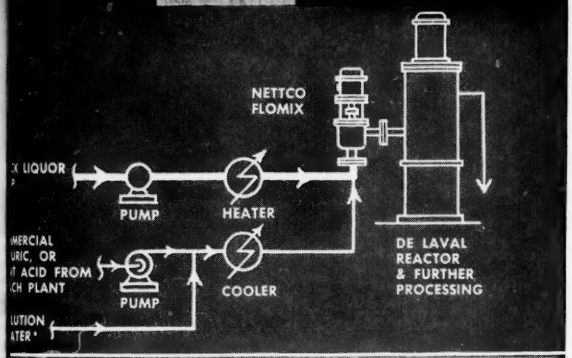
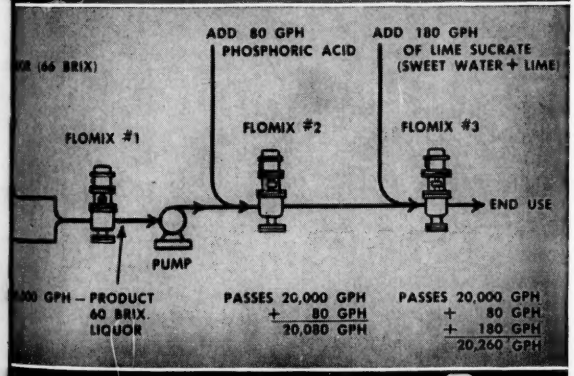
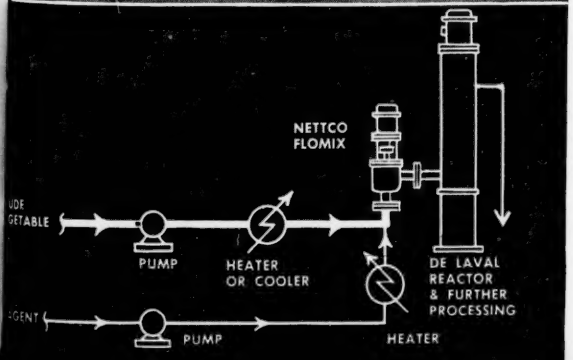


Improved Processing through Engineered Agitation






ADD 80 GPH PHOSPHORIC ACID
ADD 180 GPH OF LIME SUCRATE (SWEET WATER + LIME)
FLOMIX #1
FLOMIX #2
FLOMIX #3
END USE
PUMP
PASSES 20,000 GPH + 80 GPH 20,080 GPH
PASSES 20,000 GPH + 80 GPH + 180 GPH 20,260 GPH



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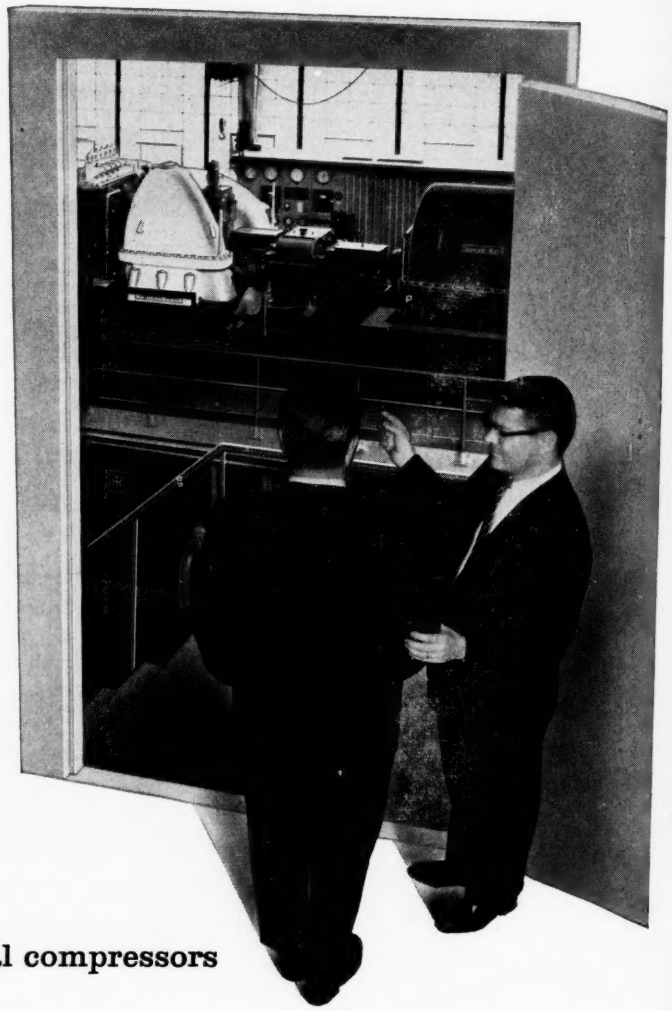
3 In **DeLaval** Continuous Centrifugal Tall Oil Process.
4 In Defecation Process in Sugar Refinery.
5 In **DeLaval** Hermetic Continuous Centrifugal Vegetable Oil Refining Process.

Adding new dimensions *to engineering*



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We go to this extra effort because testing under closely simulated operating conditions takes the guesswork out of compressor performance. And these same facilities also aid our research and development in new fields of air and gas compression.

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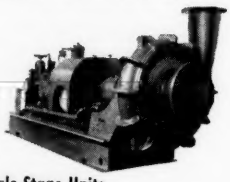
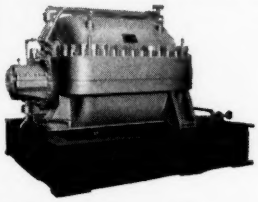
Why Ingersoll-Rand can supply EXACTLY WHAT YOU WANT in a Centrifugal Compressor

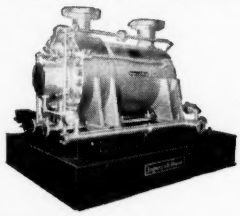
MORE TYPES AND SIZES to choose from



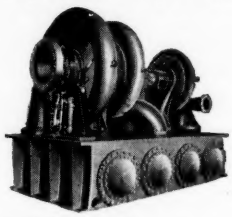
Single-Stage Units
Pressures to 1000 psi
Capacities to 700,000 cfm



Multi-Stage, Horizontally Split
Pressures to 800 psi
Capacities to 200,000 cfm



Multi-Stage, Vertically Split
Pressures to 5500 psi
Capacities to 20,000 cfm



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from Whiskey Island in the industrial area of Cleveland, connect the surface with the salt deposit 1,800 ft. below. Official opening of the mine is planned for next summer.

Swift & Co.'s total sulfuric acid capacity will be tripled when its new contact acid plant in Agricola, Fla., is brought on stream (tentatively, next April). Construction is already under way.

Tuloma Gas Products Co., an affiliate of American Oil Co., is enlarging its storage facilities by constructing an underground storage terminal at Wood River, Ill. The terminal will provide storage capacity for 150,000 bbl. of propane and a separate cavity for 50,000 bbl. of propylene. The caverns are being hollowed from solid limestone, 335 ft. below the earth's surface. When completed, liquid propane will be pumped directly from the American Oil refinery at Wood River to the terminal. Aboveground equipment includes testing apparatus and 500 gal./min. transport loading facilities.

Du Pont is installing facilities at its neoprene plant in Louisville, Ky., for manufacture of vinyl fluoride, the monomer of Tedlar, Du Pont's polyvinyl fluoride film. Construction was started in August and is expected to be finished next year. The plant's product will be shipped to Buffalo, N. Y., for polymerization.

Hercules Alclor Chemical Co., Painesville, Ohio, has completed its new anhydrous aluminum chloride plant at Gettysburg, Pa. Made from chlorine and prime metal, the product is to be sold in drum or bulk lots.

Standard Oil Co. (Ky.) and **Standard Oil Co. of Calif.** have confirmed the selection of Pascagoula, Miss., as the site for a proposed $125-million refinery. Go-ahead awaits ratification by Mississippi voters of two changes in the state's constitution, designed to ease corporate tax and land-leasing laws (special election: Oct. 3. To be built on a 3,000-acre tract east of Pascagoula Harbor, the refinery will process crude at a rate of 100,000 bbl./day to provide products for Standard Oil Co. (Ky.) marketing operations.

Companies

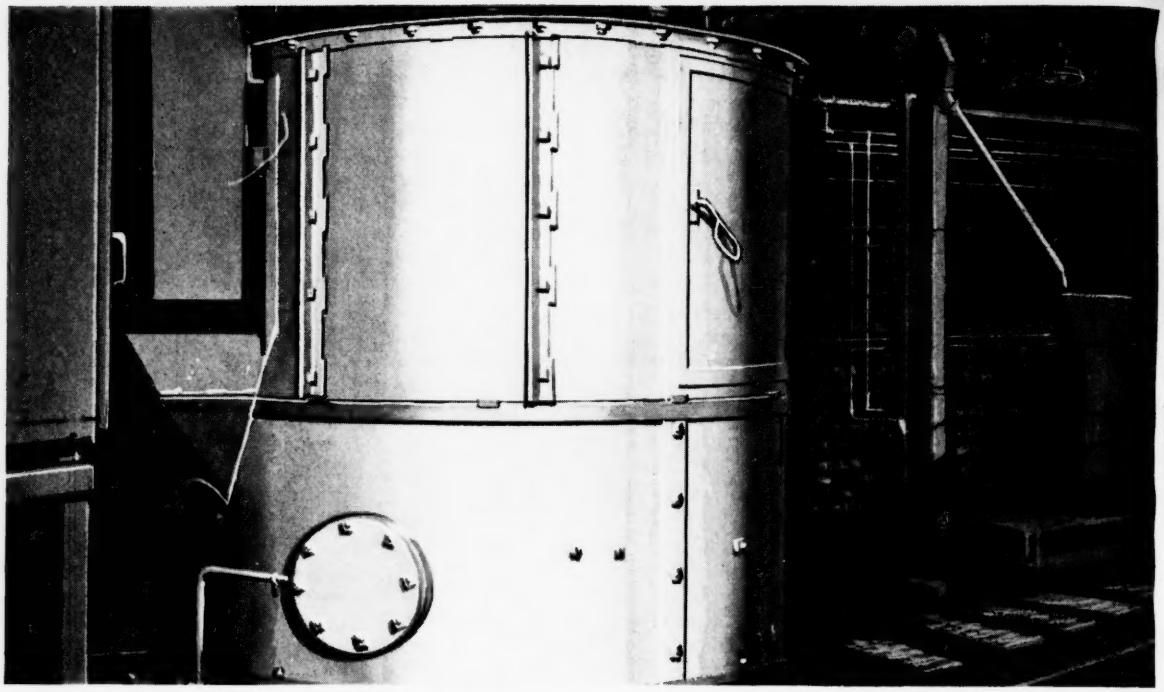
Diamond Alkali Co. and **The Bessemer Limestone and Cement Co.** have merged, stockholders of the latter receiving one share of a new Diamond preferred issue for every three shares of their Bessemer common. Diamond Alkali has renamed its acquisition Bessemer Cement Co., will operate it as a division.

Cities Service Co. and **Columbian Carbon Co.** have agreed to merge. Subject to approval of stockholders, the merger proposal provides that shareholders of Columbian Carbon will receive, for each share of their stock, a two-thirds share of cumulative-convertible preferred to be issued by Cities Service.

Glidden Co. has decided to call its four major divisions "groups". The change of name is designed to eliminate confusion caused by present "division within divisions" company structure. The four new units are: The Coatings and Resins Group, The Durkee Famous Foods Group, Chemicals Group, and International Group.

Catalin Corp. of America has acquired Lebec Chemical Co., Paramount, Calif. The addition will supplement Catalin's line of products which currently include phenolic, cresylic, resorcinol, melamine and acrylic resins as well as urea.

U. S. Borax & Chemical Corp. and **Vitro Chemical Co.** have signed a rare-earth marketing agreement. U. S. Borax will exclusively distribute Vitro rare-earth products to the glass and ceramic industries in the U.S., Canada and Mexico. Vitro will continue to market these



Foundries Discover QO® Furfuryl Alcohol (FA®) as a Resin Modifier

New doors to progress in the foundry industry are being opened by the unusual properties stemming from furfuryl alcohol modified urea-formaldehyde resins. These resins offer many new approaches and economic advantages in the production of dimensionally accurate cores, used in casting a variety of metals.

Here are some of the outstanding features of the furfuryl alcohol modified resin that have made possible the development of the high speed "hot core box" process:

1 Hot strength increases as the FA content increases, making possible the formulation of binders used in casting metals from aluminum to steel.

2 Gas evolution—both rate of evolution and total gas evolved decrease as FA content increases.

3 High solvency allows use of high solids UF resins with low viscosity. This eases the distribution of the binder, assuring strong uniform cores and enables cores to be cured rapidly.

4 Resists overcure—permitting cores to be cured over a wide range of conditions.

These properties combine to give a family of binders for the production of strong, accurate cores at a fraction of the time required with other binders. These are the properties that improve production efficiency to make more profitable end products.

For specific information, write to the Quaker Oats offices listed below.

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Room 535Z, 120 Wall St.,
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Room 435Z, 49 S.E. Clay Street
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In the United Kingdom:
Imperial Chemical Industries, Ltd., London, England

In Europe:
Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France;
Imperial Chemical Industries (Holland) N.V., Rotterdam, Holland
Imperial Chemical Industries (Export) Ltd., Frankfurt a.M., Germany

In Australia:
Swift & Company, Ltd., Sydney

In Japan:
F. Kanematsu & Company, Ltd., Tokyo

products in industries not normally served by U. S. Borax.

Enjay Chemical Co. and **J. P. Stevens & Co., Inc.,** are purchasing the operating assets and facilities of The National Plastic Products Co. Enjay and Stevens have formed a new jointly owned company that will operate under the National Plastic name and present management.

Union Carbide Middle East Co. has filed articles of incorporation with the Delaware Secretary of State's office. Amount of authorized capital stock is listed as 250 shares.

International

Netherlands: Chemische Industrie Synres, N.V., will build a phthalic anhydride plant at Hoek van Holland. Owned jointly by Allied Chemical Corp. and Synres, the plant is to be completed during the fall of 1962 by Badger N.V.

United Arab Republic's state-held Egyptian Chemical Industries Co. (KIMA) is reported to have commissioned or to be about to commission four more nitrogenous fertilizer units at Aswan, each with an ultimate capacity of 400 tons/yr. of ammonium calcium nitrate. Also in the wind is a $20-million aluminum project for Aswan, contract for which is being negotiated. Earlier this summer, KIMA announced plans for a 22-ton/yr., $8.4-million deuterium installation at Aswan (*Chem. Eng.*, July 24, p. 182); cost estimates for this project have been upped to $10 million.

Canada: Cyanamid of Canada Ltd. plans a diammonium phosphate unit at its Welland, Ont., complex. First phase will cost $2 million, include facilities for producing granular triple superphosphate. Expansion of the site's ammonia plant is also scheduled.

Argentina: The Borden Chemical Co. has announced completion and

Pulsafeeder meters "skunk essence" with never a whiff of leakage

Metropolitan Utilities District of Omaha adds skunk-like odorants to natural gas to warn customers of leaks. At first there were problems: odorization varied with gas flow rates; odorizing equipment often broke down under high loads; neighbors complained about leakage of the odorant.

Then, four years ago, Lapp Auto-Pneumatic Pulsafeeders took over the job. Since then, pump leaks have been non-existent. Adjustments that used to take hours are made in seconds. Maintenance costs 95% less. Odorization is absolutely uniform. And based on present conditions, Metropolitan Utilities estimates their Pulsafeeder Pump life to be over 20 years.

If your material is hard to handle . . . if you're looking for accurate metering . . . if high maintenance costs are eating into your profit . . . it's time to put Pulsafeeder to work for you.

WRITE for Catalog 59. Lapp Insulator Co., Inc. Process Equipment Division, 1122 Poplar Street, LeRoy, New York.

New, Informative Film "HARD TO HANDLE"

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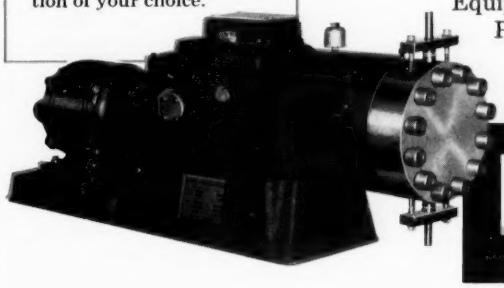


Lapp

Which AC/DC digital voltmeter should you buy?

...seven questions to help you decide

1. Is it reliable, dependable?

A rather general question, and one you often get rather general answers to. But with such an important consideration, you should get answers like these:

The stepping switches in the KIN TEL 502B AC/DC digital voltmeter are guaranteed for two years. KIN TEL can make this guarantee because it operates stepping switches conservatively, driving them with DC (as in telephone service) at a rate somewhat below their peak speed. This gentler drive gives the 502B a longer life, makes it capable of more sensitive measurements, eliminates the need for stepping switch adjustments or other maintenance, and greatly reduces down time.

When servicing is ultimately needed, KIN TEL-trained personnel in 22 different maintenance shops throughout the country are prepared to put your 502B in factory condition with minimum delay.

Each 502B is manufactured on a true production-line basis. KIN TEL has used this method in building over 10,000 "standard-cell-accuracy" instruments, instruments known for their consistent, trouble-free performance.

2. Does it have automatic range selection for AC and DC?

Auto-ranging is a convenience. It makes your job a little easier, a little surer. It permits unattended operation with a printer to record voltages on the range giving the best resolution.

The KIN TEL 502B has it.

3. Does it have a single-plane readout?

A single-plane readout reduces reading errors. Each number is displayed individually. There are no superimposed outlines of "off" digits. You can read the numbers as easily from the side as from the front.

The KIN TEL 502B has a single plane readout.

4. Can you program it?

A programable instrument is a more useful instrument. It can be used with a printer for unattended checkout of missile components, quality control of specific items, and other automated measurements.

You can program the 502B. It's one of the two standard, off-the-shelf digital voltmeters controllable by remote contact closures. With the AC converter control set to REMOTE, closures command any desired sequence of measurements at 10-volt AC, 100-volt AC, 1000-volt AC, auto-range AC, or auto-range DC.

5. Will it over-range on both AC and DC?

A loaded question, perhaps, since the KIN TEL 502B is the *only* digital voltmeter on the market with 100% over-ranging on AC and DC. But this is an important feature, not just an extra one.

The 502B displays 4 complete digits plus a 5th over-ranging digit (0 or 1). This 5th digit gives ten times more resolution at the often-measured decade points (1,10,100 volts) than 4-digit voltmeters that lose a digit changing from .9999 to 1.000. This means you get the useful accuracy of a 5-digit voltmeter over a large part of the measurement range while retaining the stability, reliability, and price advantage of a 4-digit instrument.

6. Does it offer the highest accuracy?

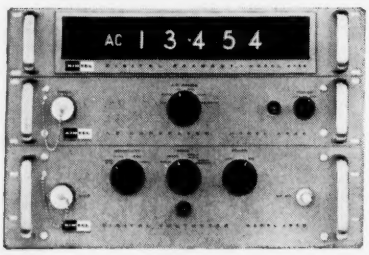
Of course, none of the features listed so far are worth a dime if you can't depend on what the instrument tells you. So let's be specific:

With the 502B, DC measurements are accurate to within .01% of reading ± one digit. AC accuracy is the highest in the industry — within 0.1% *of reading* or ± 3 digits (0.03% of full scale) for signals between 30 cps and 10 kc up to 10.000, 100.00, or 1000.0 volts on the respective range scales. With manual or programed ranging, this same accuracy is maintained up to 15.000 or 150.00 volts for signals between 50 cps and 7 kc.

This accuracy is maintained by a constant and automatic calibration of the metering circuit against an unsaturated mercury-cadmium standard cell.

7. Is it worth what it costs?

The KIN TEL 502B costs $4245, and is delivered from stock. Compare it – what it does and what it costs – with any other AC/DC digital voltmeter. We think that when you do, the 502B will rate the same answer on this question that it has on the other 6: yes.



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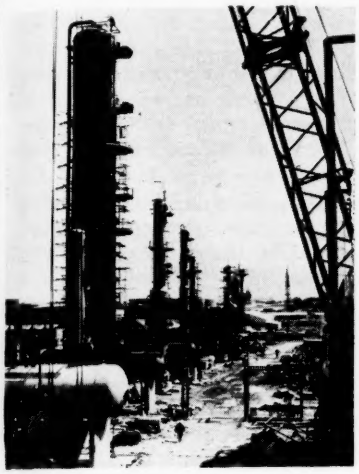
startup of its resin plant in Pilar, to produce 13 million lb./yr. of formaldehyde and 6.6 million lb./yr. of urea and both phenolic and resorcinol resins. Products are to be sold locally.



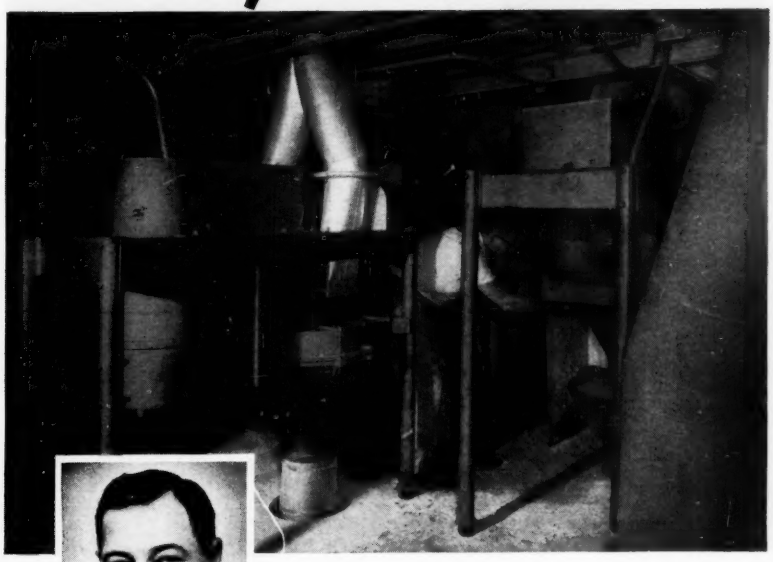
Denmark: Dansk Veedol, a wholly owned subsidiary of Tidewater Oil Co., has officially dedicated its $20-million, 20,000-bbl./day refinery (*above*) at Kalundborg, near Copenhagen. Storage capacity at the 550-acre site is enough to provide a 20-day petroleum supply for all of Denmark.

Mexico: Du Pont and Petroleos Mexicanos (Pemex) are joining forces to manufacture antiknock automotive and aviation gasoline. The American company and Mexico's nationalized oil industry plan to start construction of an $8-million complex by early 1962. According to a Du Pont spokesman, the most likely site is Parjaritos Island, lying in Coatzacoalcos on Campeche Bay in southeastern, oil-rich Veracruz state. On a 20-acre site, a Du Pont plant will produce tetraethyl lead; an adjoining Pemex petrochemical complex will turn out ethyl chloride and ethylene dichloride, both of which will be fed to the Du Pont operation. Pemex products will also include vinyl chloride.

Colombia: The Borden Chemical Co. has started up its synthetic

JOHNS-MANVILLE decides on Entoleter

Impact Mills



E. C. Truax, Manager of Johns-Manville's Nashua plant, says Entoleter Impact Mill is the only machine that can do all three jobs in the preparation of asbestos cement-board: *Fiberizing* of ore, *reduction* of agglomerates, and thorough smooth *blending* of asbestos fiber, cement and pigment.

The principle of the Centrifugal Impact Mill (high-energy centrifugal force plus shattering impact) is used by many manufacturers for controlled *particle-size reductions,* and for *elimination of agglomerates* and for *fast blending* of ingredients into a smooth-textured, homogenous mixture of dependably consistent quality.

The high efficiency and the low H.P. requirement of the Entoleter Impact Mill make it highly desirable in processing for *mixing, grinding,* and the intimate *dispersion* of trace ingredients.

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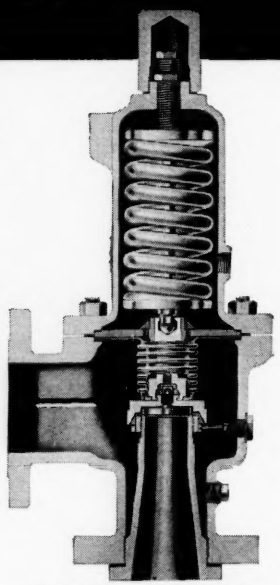

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- **Elimination of effects of back pressure by "BALAN-SEAL" bellows permits use of smaller discharge piping . . . Saves up to 15 times the cost of the valves . . . isolates internal working parts from lading fluid.**
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Series 2740 & 2741 . . . simple, rugged cast steel design. Pressures to 5000 psig @ 750°F.

Series 2745 . . . Durable, compact, high pressure nozzle valve. Internal parts 316 stainless steel. Pressures to 10,000 psig.

Series 2950 . . . Cast iron valve similar to Series 2600. Max. pressure 250 psig. @ 450°F, 400 psig. @ 150°F.

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resin facilities in Cali. Designed to produce 6.6 million lb./yr. of urea, phenolic and resorcinol resins and 13 million lb./yr. of formaldehyde, the plant will supply local industries.

France: Du Pont and Etablissements Kuhlmann S.A. plan to set up a joint affiliate dubbed Dekachimie to manufacture isocyanates at La Madeleine, near Lille in northern France, for sale to the six Common Market nations. Capitalization is pegged at $6.1 million, construction will start early next year, be completed in 1963. Meanwhile, isocyanates from U. S. will be sold by new company.

Canada: Imperial Oil Ltd. will spend $3 million on additional distillation equipment to raise capacity of its Sarnia refinery to 110,000 bbl./day from the present 94,000-bbl./day throughput. The additional facilities are needed by 1963 to meet government's policy for use of Canadian crude.

Ireland plans to establish a state-subsidized $16.8 to $22.4-million nitrogenous fertilizer industry at Arklow, 60 miles south of Dublin. Ministry announcement gave no details on financing, capacity or construction dates of the proposed plants (which will "provide a basis for several subsidiary industries using chemical byproducts"), but raw materials will be pyrites from the nearby, extensive St. Patrick copper mine.

Brazil: Standard Beryllium Corp., New York, and Beryllium Resources, Inc., Los Angeles, have announced the world's first large-scale flotation mill to concentrate beryl ore by the Van Dornick process. Due on stream early next year, the 2,500-ton/yr. plant will be built at Boa Vista, Minas Gerais province, Brazil. Boa Vista is the site of a huge, rich beryl deposit owned by Standard Beryllium; Beryllium Resources owns the continuous flotation route. Former firm will create a new, as-yet-unnamed subsidiary to be the plant's operator, 10% equity in which (plus undisclosed

royalties) will go to Beryllium Resources in exchange for the process.

Argentina: Industrias Quimicas Sociedad Anonima Industrial y Comercial (Duranor) plans a 25-ton/day petrochemical phenol plant at Rio Tercero, Cordoba province, 450 miles north of Buenos Aires. Facility will also produce 100 metric tons/mo. of monochloro benzene for sale over and above its own needs; and a byproduct unit will make dichloro benzenes for sale as well. Duranor is jointly owned by Hooker Chemical Corp. and Compania Nacional para la Industria Quimica, S.A.M. (Atanor).

Canada: U. S. Borax & Chemical Corp. and Homestake Mining Co. have teamed to complete studies on large-scale potash production in Saskatchewan, where U. S. Borax has been investigating permits held since 1957. If the completed studies indicate that such production is feasible, the two companies may participate equally in a company formed for such a purpose.

India's state-held Nangal Fertilizer Co. schedules a November on-stream date for its 14.5-ton/yr. deuterium plant at Nangal, Punjab state. Installation is one of the chief units at Nangal's sprawling, $60-million fertilizers complex, initial production at which began in the early spring (*Chem. Eng.*, Apr. 17, p. 218). Since February, the complex has produced 45,000 tons of fertilizer; ultimately, capacities at the site will be 80,000 tons/yr. of nitrogen, 350,000 tons/yr. of ammonium sulfate.

People

Raymond H. Herzog and **Harry Heltzer** have been elected vice presidents of Minnesota Mining & Mfg. Co., St. Paul. At the same time, the Minnesota firm announced the election of three divisional vice presidents: **E. J. Kane** for the printing products division,

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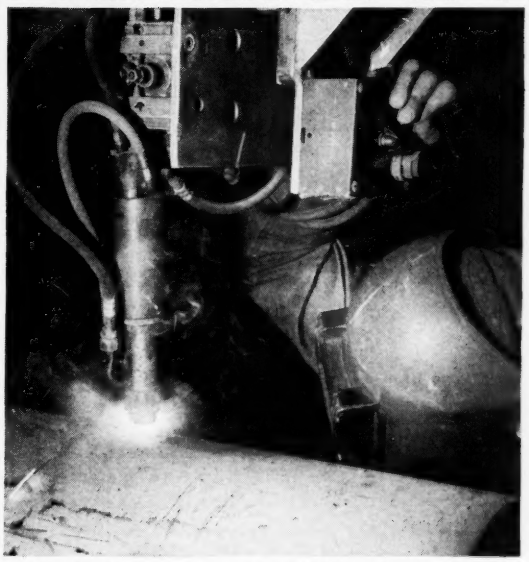

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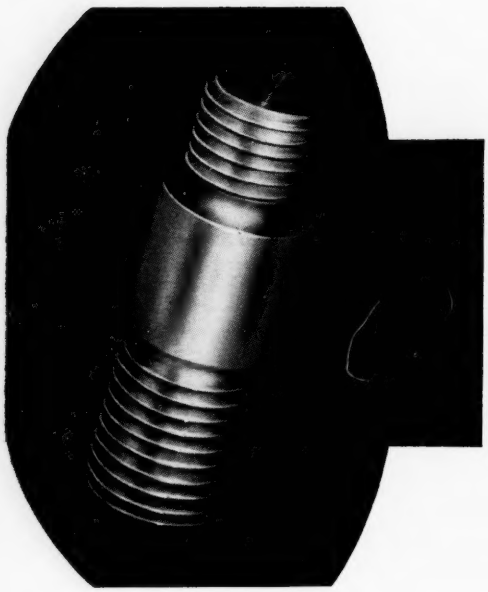
Bolts made of Armco 17-4 PH Stainless Steel galling, corrosion, heat, and high

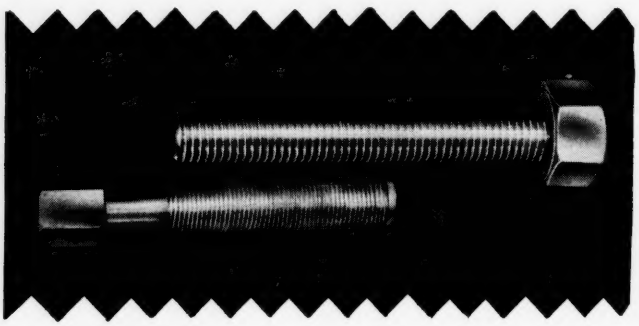
Service in wide range of processing equipment demonstrates utility and economy of this special Armco Stainless Steel as bolting material.

Many equipment manufacturers and plant engineers have eliminated troublesome bolting problems because Armco 17-4 PH offers a unique combination of properties.

. . . Ultimate tensile strength up to 200,000 psi.
. . . Yield strength (0.2% offset) as high as 180,000 psi.
. . . Elongation in 2" from 12% to 19%.
. . . Hardness as high as Rockwell C 44.
. . . Useful mechanical properties up to 500 F.
. . . Corrosion resistance comparable to Type 304 stainless in most media.
. . . Good fabricating characteristics.
. . . Short-time, low-temperature heat treatment (900-1150 F).
. . . Properties can be varied to meet specific needs by selection of hardening temperature.

for Durability, Strength and Economy





For bolting exposed to severe service conditions, Armco 17-4 PH performs as well as or better than more expensive alloys. It has corrosion resistance superior to regular hardenable stainless steels, and much greater strength and hardness than the "300" stainless grades. It assures reliable performance and helps cut maintenance costs.

The properties of 17-4 PH that make it so useful in bolting also make it advantageous for pump shafting, valve stems and trim, and other applications in processing equipment.

Write us or contact your Distributor of Armco Stainless Steels for information on the properties and uses of Armco 17-4 PH Stainless Steel. **Armco Division, Armco Steel Corporation, 2991 Curtis Street, Middletown, Ohio.**

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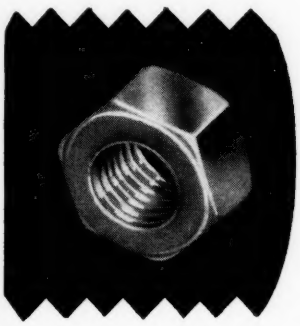

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ESCO CORPORATION **Portland, Oregon**—Denver—Emeryville, Calif.—Eugene, Oregon—Honolulu—Los Angeles—Seattle—Spokane—Vancouver, B. C.	(AB)
PETER A. FRASSE & COMPANY, INC. **New York, N. Y.**—Buffalo—Hartford—Lyndhurst, N. J.—Philadelphia—Syrcause	(AB)
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EARLE M. JORGENSEN COMPANY **Los Angeles, Calif.**—Dallas—Denver—Honolulu—Houston—Oakland—Phoenix—Seattle—Tulsa—Witchita	(AB)
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MONCRIEF-LENOIR MFG. COMPANY **Houston, Texas**—Dallas—Harlingen—Lubbock—San Antonio—Temple	(AB)
MORRISON STEEL COMPANY New Brunswick, N. J.	(AB)
THE ORLEANS STEEL PRODUCTS COMPANY, INC. New Orleans, La.	(A)
WILLIAM M. ORR COMPANY, INC. Pittsburgh, Pa.	(AB)
PAPER-CALMENSON & COMPANY St. Paul, Minn.	(A)
SEABOARD STEEL & IRON CORP. Baltimore, Md.	(B)
SENECA STEEL SERVICE, INC. Buffalo, N.Y.—Jamestown, N. Y.	(AB)
SOUTHER STEEL & ALUMINUM COMPANY St. Louis, Mo.	(A)
J. M. TULL METAL & SUPPLY COMPANY, INC. **Atlanta, Ga.**—Birmingham—Greenville, S. C.—Jacksonville—Miami—Tampa	(AB)
VIKING STEEL COMPANY Cleveland, Ohio	(AB)
VORYS BROTHERS, INC. Columbus, Ohio	(AB)
YORK CORRUGATING COMPANY **York, Pa.**—Washington, D. C.	(A)

CPI NEWS BRIEFS . . .

A. H. Redpath for the retail tape and gift wrap division, and **R. W. Adam** for the industrial tape division.

Wallace A. Senten is the new manager for the Mexican branch of Allied Chemical Corp.'s subsidiary, Allied Chemical International Corp. The Mexican branch serves not only Mexico but also the rest of Central America.

Reginald F. Webb has been appointed director of research for Allied Chemical Corp.'s Plastics Div. His headquarters will be at the firm's research center in Morris Township, N. J.

Thomas L. Gresham has been elected a vice president of Air Products & Chemicals, Inc., Allentown, Pa. He was vice president for research and development at A. E. Staley Mfg. Co. before joining Air Products recently.

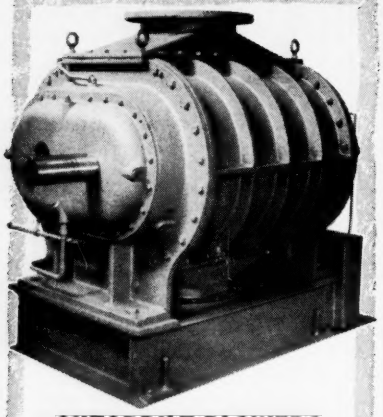
Vincent V. Lindgren is the new manager of research and development for Arizona Chemical Co., a joint-venture firm of American Cyanamid Co. and International Paper Co.

Samuel D. Koonce has been named to the newly created position of manager of commercial development for The Lummus Co., New York.

H. E. Martin has become chairman and chief executive officer of Metal & Thermit Corp., New York. Replacing him in his former position as president is **Charles J. Beasley,** who has been a vice president and secretary of the corporation.

Vincent deP. Gerbereux, formerly general manager of Worthington Corp.'s Standard Pump Div., has been named director of marketing for the firm. He will be located at Worthington's headquarters in Harrison, N. J.

Joseph C. Abeles, president of Kawecki Chemical Co., Boyertown, Pa., is now also a newly elected director of Firth Sterling, Inc., Pittsburgh.



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Sutorbilt Series 3200 Blowers and Gas Pumps for large capacity air requirements.

One-piece shafts, precision machined helical timing gears, and special timing hub are a few outstanding features recommending Series 3200 blowers and gas pumps for chemical plant applications where equipment must operate continuously against varying pressures.

Absence of internal lubrication insures the delivery of gas or air free from contaminating lubricants. As a positive displacement blower, the Sutorbilt unit delivers a metered amount of air measured at inlet conditions with each revolution.

Rated from 800 to 23,000 cfm at pressures from 2 to 12 psig, these heavy-duty units are available with timing gears from 10" to 26". Standard equipment includes machined sub-bases, reversible oil pump with oversized oil sump, and lip-type oil seals (mechanical seals in gas and vacuum pumps) to prevent leakage and gas contamination. Vertical and horizontal types available in many sizes in both series. Write today for Bulletin No. S-32-A.

Sutorbilt Blowers for smaller capacity requirements — California Series B Blowers . . . for higher speeds, greater outputs.

Thrust bearing on drive shaft permits V-belt or direct drive. Steel timing gears for extra long service. Dynamically balanced impellers for high-speed operation. Write for Bulletin S-59-I, Dept. A.

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Convention Calendar

October

8-11. American Institute of Mining, Metallurgical and Petroleum Engineers, Society of Petroleum Engineers, Fall Meeting, Dallas, Tex.

8-12. Water Pollution Control Federation, Milwaukee Auditorium and Schroeder Hotel, Milwaukee, Wisc.

9-11. Technical Assn. of the Pulp & Paper Industry, Plastics Paper Conference, French Lick-Sheraton Hotel, French Lick, Ind.

9-15. American Rocket Society, Space Flight Report to the Nation, New York Coliseum, New York, N. Y.

10-12. 2nd Conference on Nuclear Reactor Chemistry, 5th Conference on Analytical Chemistry in Nuclear Reactor Technology, Oak Ridge National Laboratory, Gatlinburg, Tenn.

10-13. 15th National Conference on the Administration of Research, University of Puerto Rico, San Juan, Puerto Rico.

11-12. CHEMICAL ENGINEERING and Armour Research Foundation, Conference on the New Trends in Chemistry, Sheraton Towers Hotel, Chicago, Ill.

11-12. Western Petroleum Refiners Assn., Waste Disposal and Stream Pollution Conference, Hotel Lassen, Wichita, Kan.

11-13. The Fiber Society, Fall Meeting, U. S. Hotel Thayer, West Point, N. Y.

16-19. American Vacuum Society, 8th Annual Symposium, Washington, D. C.

16-19. Technical Assn. of the Pulp and Paper Industry, 16th Engineering Conference, Shoreham Hotel, Washington, D. C.

16-20. National Safety Council, 1961 National Safety Congress and Exposition, Chicago, Ill.

17-18. The American Society of Mechanical Engineers, Bulk Solids Handling Symposium, The Pick-Nicollet Hotel, Minneapolis, Minn.

17-19. Plastics Show of Canada, Automotive Bldg., Toronto, Canada.

17-19. American Society of Lubrication Engineers, American Society of Mechanical Engineers, Joint Lubrication Conference, Morrison Hotel, Chicago, Ill.

18-19. The Commercial Chemical Development Assn., Economic Evaluation in New Project Appraisal, Palmer House, Chicago, Ill.

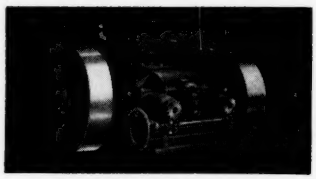
Take Guesswork Out of Lab Crushing & Grinding

Sturtevant Design Provides Easy Access for Cleanouts — Returns Complete Sample

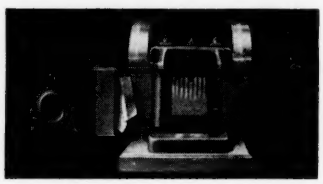
In seconds, because of "Open-Door" accessibility, all Sturtevant crushing or grinding parts are exposed for thorough cleanouts. 100% sample return is easy to secure.

Sturtevant laboratory machines are ruggedly constructed — design, based on production models, gives top lab or pilot performance.

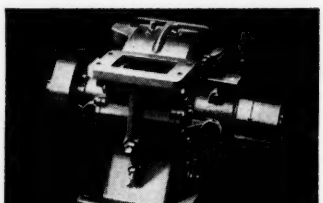
Send for Bulletin No. 067, which gives full description of all Sturtevant laboratory machines.



Lab Crushing Rolls: Special lab design. Two models: 8 x 5 in. and 12 x 12 in. rolls. Capacities to 10 tph. Both models adjust down to 20 mesh. Tires of high carbon forgings. Automatic feeder, adjustable controls.



Lab Jaw Crusher: Crushes hardest rocks at ½ to ⅛ in. settings. Roll jaw action — no clogging. Feed opening 2 x 6 in. Capacity to 1900 lbs. per hr. at ½ in. setting. Instant adjustment. Manganese jaws, reversible shield.



Lab Swing-Sledge Mill: 5 x 6 in. opening takes soft, medium, tough or fibrous feed. Capacity to 1 tph. Fines regulate from 1 in. to 20 mesh. Choice of gratings, hammers (or knives).

Sample Grinder: Disc type grinders for dry, friable soft or medium materials. Three sizes — 6 in., 10 in., and 14 in. take feed as coarse as ¼ in. Produces 100 mesh fines at capacities to 200 lbs. per hr. on largest model. Regulate 10 to 100 mesh. In-operation adjustment.

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"LOW FIRST-COST VS. LOW ULTIMATE COST" CONTROVERSY DEMANDS UNDERSTANDING OF ECONOMICS

In the price-economy of competitive bidding, especially in the field of capital process equipment, the historic struggle between long-range economy and "low-dollar" first-costs has been brought into sharp focus by modern cost engineering practices. Calculating and evaluating the eventual profitability of such equipment can no longer be a matter of "guestimates" or conjecture. The practical facts of economic life must be faced. Process companies must scrutinize closely ALL the factors concerned in engineering, construction, installation and **continued operation**. Unanticipated maintenance or replacement costs can quickly increase the cost of operation, and supposed first-cost savings are thus virtually or entirely eliminated.

Why is "cost engineering", or engineering economics an exotic term to most engineers? This is the Age of Specialization, and so it follows, given free rein, over-design frequently occurs. At the other extreme is the "gimmick pushers" approach that anything will suffice if the price is right. Between these two extremes the dedicated engineer must establish parameters that will satisfy to the highest degree the three M's of industry — Men, Materials, and Means.

Faced with these problems, then, how can we best solve the problem: "When is a low bid really low?" A multitude of answers must contribute to the total solution. What is the longevity of the equipment? How many spare parts will be required? How often will shut-down be required to make repairs? How much time will be required? What are the economic consequences of shutting down the continuous flow operation?

Cost-and-economy consciousness is of prime concern in each stage of process equipment manufacture — from design through fabrication, and finally to installation and operation. All aspects of true costs must be considered, not simply those which are obvious at the moment.

Infinite care must be exercised when considering the following:

Design — a major factor involved in the creation of process equipment. During the design phase, the greatest waste often results from a desire to be conservative. True economy in design must, therefore, satisfy the criteria which apply to each particular process.

Payout — management is interested in equipment that will pay out in the shortest period of time, and this would seem to indicate buying only what is required, at the lowest cost, at the time it is needed. Again, however, the life of the equipment, its maintenance, shut-down time and other factors cannot be ignored.

Excess-capacity — each piece of equipment must be designed for its specific use in order to obtain maximum benefit of capital dollars. Excess-capacity equipment, purchased without specific anticipation of future expansion, represents idle investment dollars.

Today's fierce competition requires the concentrated application of both short and long term economies, from design through final construction and operation. **This subject is treated in more detail in our Booklet E-4, "Low First Cost vs. Low Ultimate Cost," and free copies await you by writing WESTERN SUPPLY COMPANY, P. O. Box 1888, TULSA, OKLA. . . . where the teamwork of science, engineering, technology and economics provide the optimum in the "cost-engineered" heat exchangers in your future.**

CALENDAR . . .

18-20. The Packaging Institute, 23rd Annual National Packaging Forum, Biltmore Hotel, New York, N. Y.

19-20. Illinois Institute of Technology, 1961 National Conference on Industrial Hydraulics, Sherman Hotel, Chicago, Ill.

19-20. American Society for Quality Control, 16th Midwest Conference, Hotel Chase-Park Plaza, St. Louis, Mo.

19-21. National Society of Professional Engineers, Fall Meeting, Hotel Roanoke, Roanoke, Va.

20. American Institute of Chemical Engineers, South Texas Section, 16th Annual Technical Meeting, Moody Civic Center, Galveston, Tex.

23-26. American Institute of Mechanical Engineers, Metallurgical Society, Fall Meeting, Pick Fort Shelby Hotel, Detroit, Mich.

23-27. American Society for Metals, 43rd National Metal Congress and Exhibition, Cobo Hall, Detroit, Mich.

23-28. Institute of Chemical Engineers of Puerto Rico, 1st Inter-American Congress of Chemical Engineering, San Juan, Puerto Rico.

24-27. National Assn. of Corrosion Engineers, South Central Region, 1961 Conference and Exhibition, Shamrock Hotel, Houston, Tex.

25-26. Illinois Institute of Technology, Armour Research Foundation, 1961 Computer Applications Symposium, Morrison Hotel, Chicago, Ill.

26-27. High-Speed Testing, 3rd Annual Symposium, Hotel Somerset, Boston, Mass.

29-1. National Lubricating Grease Institute, 29th Annual Meeting, Rice Hotel, Houston, Tex.

30-1. Canadian Manufacturers of Chemical Specialities Assn., 4th Annual Meeting and Conference, Royal York Hotel, Toronto, Ont.

November

1-3. Industrial Management Society, Industrial Engineering and Management Clinic, Pick-Congress Hotel, Chicago, Ill.

2-3. American Institute of Mining, Metallurgical and Petroleum Engineers, Annual Meeting, Los Angeles, Calif.

Later

November 27-December 1. 28th Exposition of the Chemical Industries, New York Coliseum, New York, N. Y.

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of pressure and differential pressure

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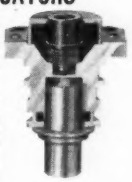

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PALL Chem Show See Booth No. 812

PALL CORPORATION

GLEN COVE, NEW YORK

Announcing

A TECHNICAL CONFERENCE

To be held under the joint sponsorship

Busy with day-to-day responsibilities and continuing pressures to meet work commitments, chemical engineers often find that advances in many fields of chemistry, not directly affecting their present job, have outdated much of their knowledge. Despite resolutions to remedy this lack, the absence of a convenient source of such information and the pressure of priority matters keeps them from following through on this resolve.

Particularly, for such men, a two-day conference on "New Trends in Chemistry" will be held in Chicago on October 11 and 12 under the joint sponsorship of Armour Research Foundation and CHEMICAL ENGINEERING. The technical program will consist of thirteen papers, covering such topics as plasma chemistry, solid-state chemistry, nonaqueous chemistry, kinetics, catalysis, inorganic polymers and radiation chemistry.

While the papers will all be given by experts, they will not be aimed at others in the same specialty but will be pitched primarily at chemical engineers who have been out of college for five or more years. Subjects will be explored in both breadth and depth. Importantly, conferees will have ample opportunity for relaxed, informal discussions.

The conference will be patterned on the highly successful "Conference on the New Chemical Engineering," which CHEMICAL ENGINEERING co-sponsored with Midwest Research Institute in Kansas City last November. It will, however, incorporate improvements suggested as a result of that first conference.

Keynote speaker will be John Turkevich, professor of chemistry at Princeton and State Department adviser on Russian technology. The banquet speaker will be General J. B. Medaris, who was formerly in charge of the Army's missile program and who has been a perceptive critic of our defense efforts. General Medaris is now president of Lionel Corp.

The $50 fee for this important and timely conference covers attendance at four technical sessions, two luncheons, a cocktail party, and a banquet. Registrants will also be supplied with a copy of each of the papers to be presented. For registration and hotel details, write T. R. Olive, CHEMICAL ENGINEERING, McGraw-Hill, New York 36, New York.

ON NEW TRENDS IN CHEMISTRY

of Armour Research Foundation and Chemical Engineering

October 11 and 12, 1961 Sheraton-Chicago Hotel, Chicago, Illinois

Program for the Conference

Morning Session, Oct. 11, 1961

Keynote Speaker
John Turkevich, Princeton University

Plasma and High-Temperature Chemistry
John L. Margrave,
University of Wisconsin

High-Pressure Chemistry
Robert H. Wentorf, Jr.,
General Electric Co.

Afternoon Session, Oct. 11, 1961

Solid-State Chemistry
F. Schossberger,
Armour Research Foundation

Inorganic Complexes
Arthur E. Martell,
Illinois Institute of Technology

Nonaqueous Chemistry
Joseph J. Katz,
Argonne National Laboratories

Evening, Oct. 11, 1961

Banquet Speaker
General John B. Medaris
Lionel Corp.

Simultaneous Morning Sessions, Oct. 12, 1961

Morning Session 1

Chemical Kinetics
Martin Kilpatrick,
Argonne National Laboratories

Chemical Thermodynamics
Ralph J. Tykodi,
Illinois Institute of Technology

Catalysis
Vladimir Haensel,
Universal Oil Products

Morning Session 2

Inorganic Polymers
Gerhardt Barth-Wehrenalp,
Pennsalt Chemicals Corp.

High Polymers
H. F. Mark and S. M. Atlas,
Polytechnic Institute of Brooklyn

Organic Semiconductors
Herbert A. Pohl,
Princeton University

Luncheon, Oct. 12, 1961

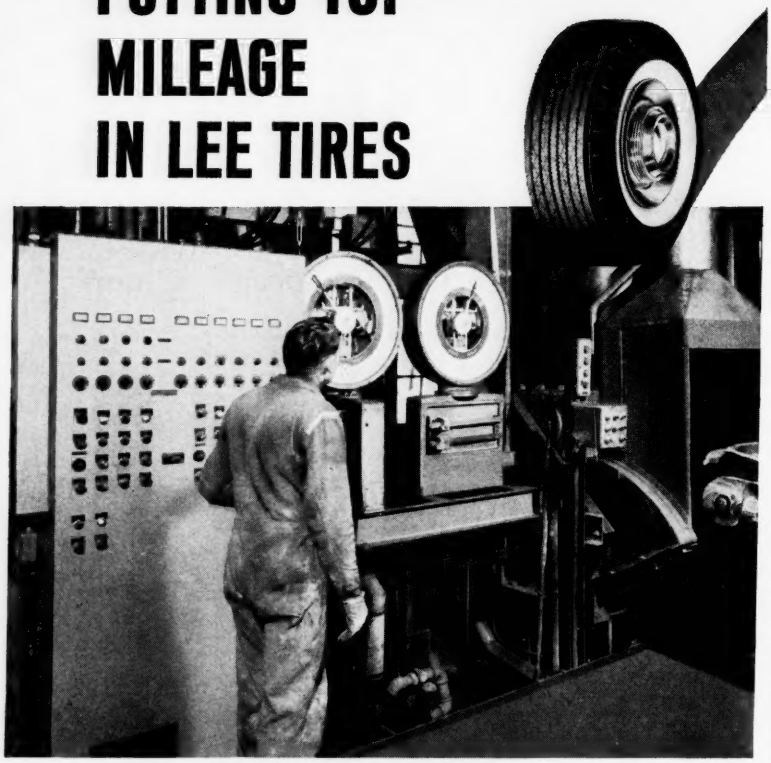
Russian Technology
John Turkevich

Afternoon Session, Oct. 12, 1961

Radiation Chemistry
Paul Y. Fang,
Armour Research Foundation

Ion-Exchange Resins and Membranes
Harry P. Gregor,
Polytechnic Institute of Brooklyn

PUTTING TOP MILEAGE IN LEE TIRES



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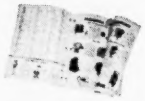
Send for free technical bulletin.



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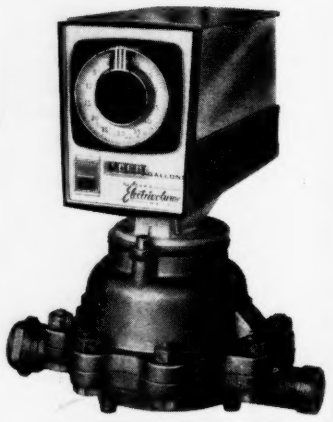
MATERIALS HANDLING BY WEIGHT SINCE 1902

(Continued from page 68)

no molecules can pass through the assembly in a straight line without striking a baffle surface. When the baffle-trap is cooled, gas molecules are removed by conventional vacuum pumping.

Cooling can be done by any of the common agents used in vacuum systems, such as water, liquid nitrogen, Freon, and also by continuous low-temperature mechanical refrigerators.

The trap can be used in vacuum systems operating in the 10^{-10} mm. Hg range.—**NRC Equipment Corp., Newton, Mass.** **68E**



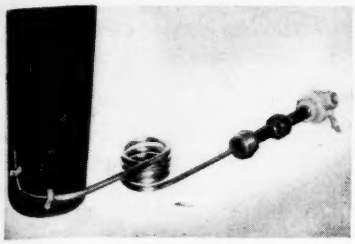
Automatic meter

Device delivers a preset quantity of liquid at the press of a button.

Called the Electrivolume meter, a new measuring device delivers a preset volume of liquid when a button is pressed. After the delivery cycle is complete, the machine is automatically reset to duplicate the delivery when the button is again pressed.

One meter can be used to actuate others, to deliver preset quantities of liquid in any desired sequence. The unit can be used to start or stop pumps, or operate solenoid valves, signaling devices, electric relays and other processing equipment.

The meters are available in many sizes and capacities.—**Buffalo Meter Co., Inc., Buffalo.** **156A**

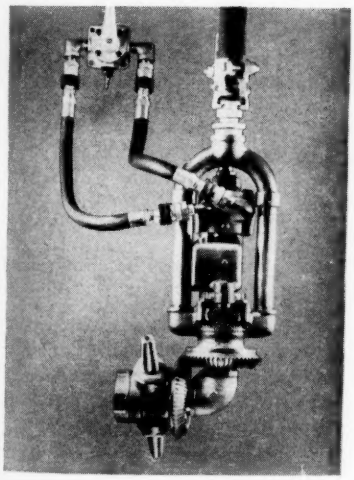


Contact thermocouple

Unit determines temperature at surface of large heater tubes.

A small pad, welded at the hot junction, makes this thermocouple particularly suitable for skin-temperature sensing. In use, the pad and sheath are welded to large-diameter heating tubes or other surfaces, to transmit temperature measurements. The unit is coiled to allow for expansion and contraction of the heated surface.

The flexible metal-sheathed thermocouple element consists of a swaged sheath containing thermocouple wire and magnesium oxide insulation.—**Trinity Equipment Corp., Cortland, N. Y. 157A**

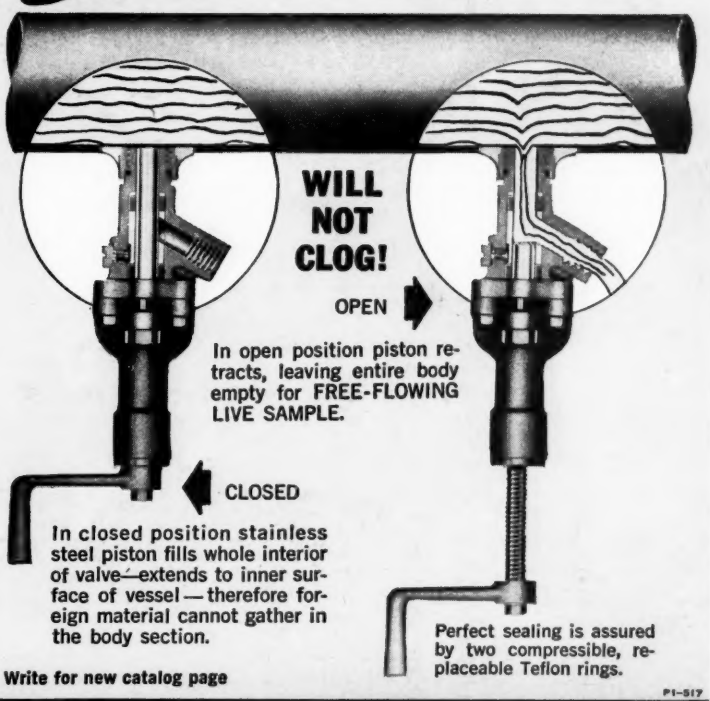


Jet tank cleaner

Reversible jet covers 360-deg. arc, scours entire interior of a tank.

Tanks of riveted-plate construction containing raised seams can be thoroughly cleaned with a jet cleaner that is reversible over the entire 360-deg. arc. On reversing,

Strahman SAMPLING VALVE


WILL NOT CLOG!
OPEN
In open position piston retracts, leaving entire body empty for FREE-FLOWING LIVE SAMPLE.
CLOSED
In closed position stainless steel piston fills whole interior of valve—extends to inner surface of vessel—therefore foreign material cannot gather in the body section.
Perfect sealing is assured by two compressible, replaceable Teflon rings.

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P1-517

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...ACCURATE METERING WITH SMOOTH CONTROL

Wallace & Tiernan's newest plunger pump delivers 3.2 gph vs 1200 psi to 50 gph vs 100 psi, repeatable within ± 1%. Easy adjustment over 10:1 range with the pump running.

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A second liquid end doubles capacity or gives simultaneous feeding of two liquids. Stroke length for each end individually adjusted.

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Unitized construction means the Series 100 Pump stays in perfect alignment. Wear and maintenance are held to a minimum. Corrosion-resistant wetted parts handle most chemicals. The Series 100 Pump, with motor, is compact. With two liquid ends it occupies less than 2 sq. ft.

For more information write Dept. L-8.29

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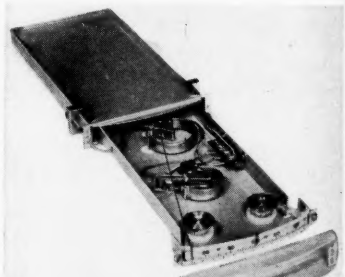
the liquid jet strikes the inside surface at a different angle, cleaning rivet heads, seams and irregularities completely.

The unit is balanced so it can be lowered into a tank by its hose without additional support. Two jets power high-pressure streams in both horizontal and vertical directions. Length of the cleaning cycle can be varied to suit the job.

Compressed air at 60 psi. is used to rotate the head, independent of the pressure or velocity of the jets. Detergent or sanitizing agents can be added in preset proportions through siphoning action.

For particularly high pressures, an attachment can be used that hydraulically combines cold water and plant steam to form a discharge at 2 to 20 times higher pressure than the inlet steam.—**Sellers Injector Corp., Philadelphia.** 157B



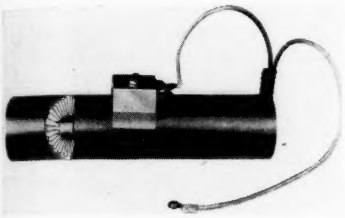
Pneumatic receiver

Readout scales may be changed by rotating preprinted plastic tape.

Multiple scales are provided on a pneumatic receiver that mounts in panel boards vertically or horizontally, to conserve space. Scales are printed on laminated plastic tape and stored on spools. When a change in process conditions requires new scale values, the desired scale is rotated into view.

Each scale is 4½-in. wide. A red set-hand is clipped on the dial and aligned as required. Receivers are adjustable from the front without disconnecting the unit from the process. An optional high/low-alarm pressure switch

operates from an independent bourdon tube to avoid overloading the pressure element used for indication.—**United States Gauge Div., American Machine & Metals, Inc., Sellersville, Pa.** 158A

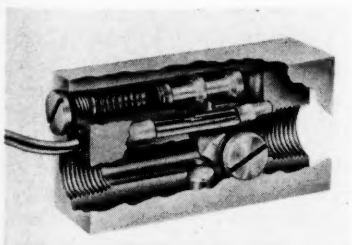


Gas-liquid heater

Unit, installed as part of piping, heats fluids uniformly to 600 F.

This handy electrical heater for gas and liquids has a scalloped internal heating element that provides uniform heating over the entire surface, thus eliminating hot spots and preventing sensitive fluids from being overheated in local areas while trying to achieve a high enough over-all temperature.

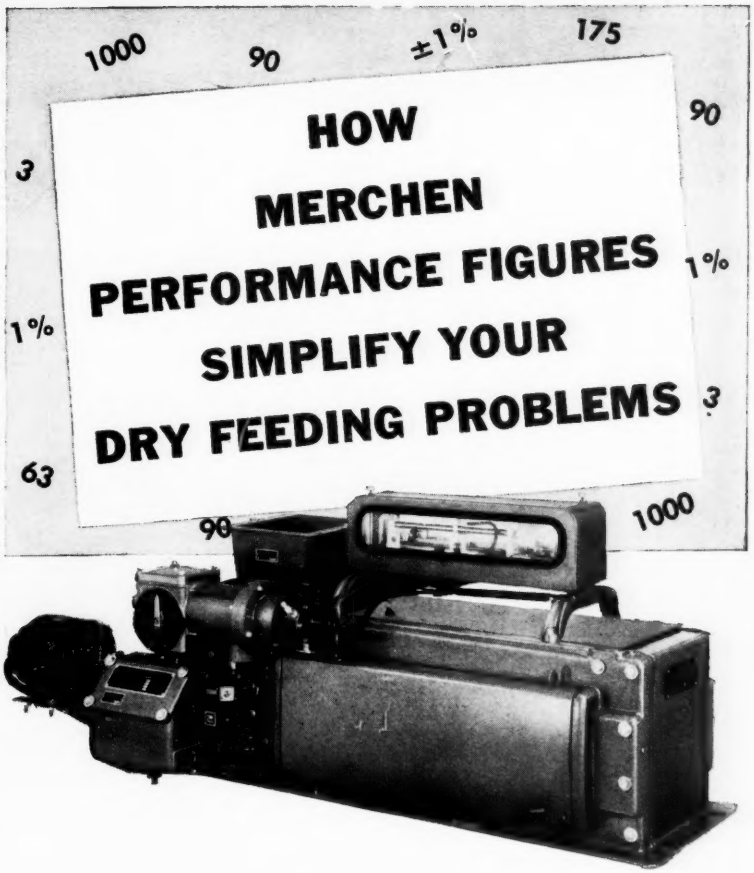
Standard unit is 9-30 in. long, with ratings of 2,500 to 9,400 w. at 115-230 v. Special wattages and platings are available. The unit has an over-temperature thermostat. Inner heating fin of copper or aluminum carries a long-life guarantee.—**Lytron, Inc., Cambridge, Mass.** 159A



Adjustable flow switch

Bypass valve provides actuation over liquid or gas flow range.

Field-adjustable to detect variations in flow rate of liquids or gases, this flow switch reveals



3 lb. to 90 tons an hour. That's the span of Merchen Feeder capacity. 1% of set rate and 1000:1. That's its accuracy and range. Coal, pigments, wheat, carbon, sawdust. These are some of the 175 common, dry, free-flowing materials a Merchen feeds with ease.

These figures tell the story of a Merchen's versatility. Whether you blend continuously or by batch, the Wallace & Tiernan Merchen Feeder simplifies your entire process. Use it as a straight gravimetric feeder, as a master proportioning other ingredients in the process, or as a slave with instant response to external pneumatic signals.

The Merchen responds to a change of just one ounce in a 63-pound belt load. That's because the Merchen weighs only actual material—never feeder components. This means constant delivery with minute-to-minute accuracy of ±1%. Corrosion-resistant construction means long, trouble-free life. And the Merchen's compact size—less than 3 ft. x 5 ft. for the largest model—lets it fit almost anywhere.

Information from Dept. M-60.29.

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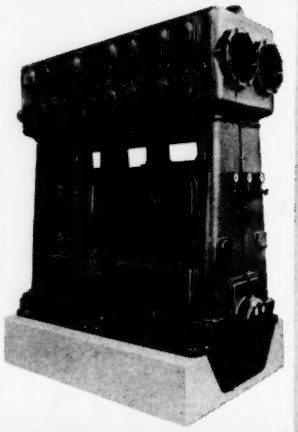
...are available for capacities from 10 to 4,000 cfm and discharge pressures up to 650 psig. The construction of these compact, standardized 1, 2 and 3 stage units are the result of Sulzer's 25 years of experience in their design and manufacture. These compressors also have a unique ringless piston and frictionless piston rod stuffing-box which requires little or no maintenance and assures absolutely contamination-free compression of Air, Oxygen, Hydrogen, Dry Chlorine and other Industrial gases. Sulzer Non-Lubricated, Ringless Piston Compressors are also available for refrigeration with capacities from 400,000 to 4,000,000 B.T.U./h. Suitable for extremely low temperatures, these Dry Piston Compressors cannot contaminate the refrigerant, preventing the formation of oil films in evaporators and condensers.



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...are available for suction volumes from 20,000 to 300,000 cfm and pressure ratios up to 5 in a single casing. Proved exceptionally economical, dependable and trouble-free for Chemical Processing, Blast Furnace and Wind Tunnel application, Air Separation Plants, etc., the Sulzer Axial Compressor features a patented blade design which resists erosion and remains unaffected by fouling.

SULZER CENTRIFUGAL COMPRESSORS are available with capacities from 2,000 to 30,000 cfm.

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changing conditions, may be used to operate a warning light or other indicator.

Displacement of a magnet-equipped shuttle actuates hermetically sealed switch contacts. An externally adjustable bypass valve provides a continuous range of actuation from 0.1 to 10 gpm (liquids) and from 0.5 to 30 cfm (gases).

The device, equipped with ½-in. ports, can be installed in any straight line of piping. Standard housings are brass or stainless steel, but aluminum, plastic or other nonmagnetic material may be used.—**The Gems Co., Inc., Farmington, Conn.** 1590

Gas density detector

Mounted on chromatograph, it can identify separated compounds.

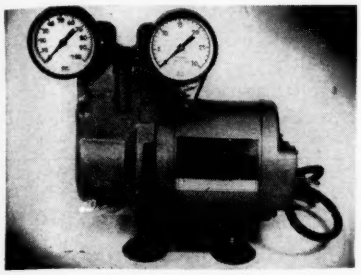
By measuring a single additive property of a gas that has been separated into component parts by a chromatographic column, a detector helps to quickly identify the various compounds. If the molecular weights of the compounds are already known, the chromatographic peak areas can be converted directly into weight per cent.

In operation, reference (carrier) gas is introduced into the detector, and split vertically into two streams that pass by an upper and lower detector element (hot wire or thermistor), cooling each the same amount.

Sample gas is introduced downstream of the detector elements; it too is split vertically into two streams that join the exiting reference gas streams. If the sample gas contains a component heavier than the carrier gas, more will flow in the lower passage than the upper, causing less carrier gas to flow past the lower detector element and more to pass the upper.

The difference in flow rate past the detectors will cause a temperature differential between the two points, unbalancing a Wheatstone bridge circuit. Bridge unbalance is linear over a wide range, and is directly related to gas density differences.

Corrosion is no problem since the sample gas never contacts the reference elements. The unit operates over a wide temperature range.—**Gow-Mac Instrument Co., Madison, N. J.** 160A



Vacuum-pressure pump

Unit can furnish oil-free air or provide vacuum for filtrations.

A compact pump provides 1 cfm. of either pressure or vacuum for pilot plant or laboratory. The unit contains built-in moisture eliminator, after-cooler, pulsation chamber, intake filter, vibration mount and muffler.

All bearings are self-lubricated, and the seal between piston and cylinder is self-adjusting through spring-loaded graphite rings. Typical applications include an oil-free air source, vacuum source for filtration and sampling, and an air pressure source for machine tools.

Model 13152 ranges from 26 in. Hg vacuum, to 65 psi. as a compressor.—**Gelman Instrument Co., Chelsea, Mich.** 161A

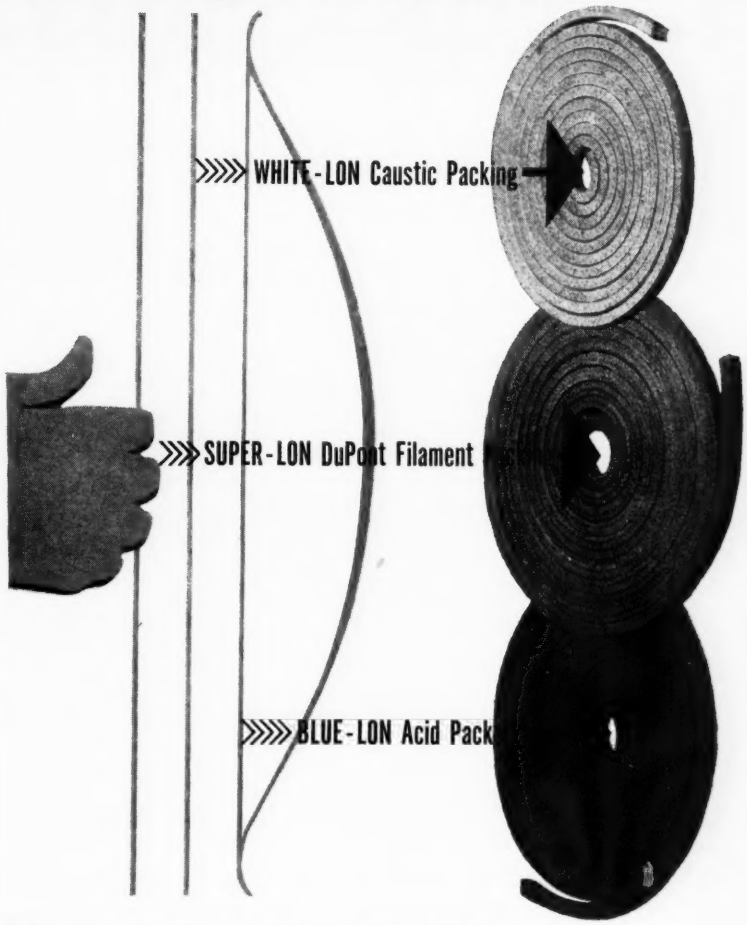
Bellows valve

Liquid metals and vapors handled at up to 2,200 F. and 1,000 psi.

Twin flex-bellows, welded to the actuating beam and valve body, serve as a main seal and a backup seal (in the event of rupture of the main seal) in this valve that can handle liquid metal and metal vapors.

Valve seats are integral parts of the inlet and outlet connections, and a hard-faced floating seal plate is an integral part of the ac-

3 Packings for Corrosives!



Hit the bull's eye in every pH range —

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SUPER-LON *for pH values 1-14* is a braided DuPont Teflon Filament Packing, brown in color. 30 times stronger than Teflon Resin Packings.

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WHITE-LON *for pH values 11-14* is a non-graphited, heavily Teflon saturated White Asbestos Packing.

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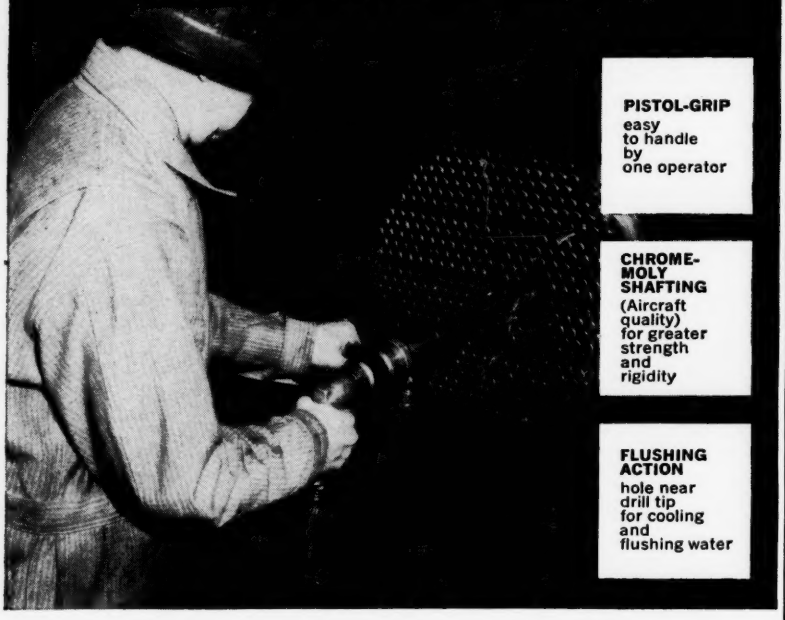
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easy to handle by one operator
CHROME-MOLY SHAFTING
(Aircraft quality) for greater strength and rigidity
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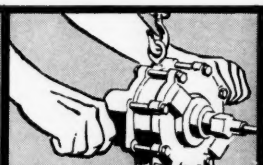
hole near drill tip for cooling and flushing water

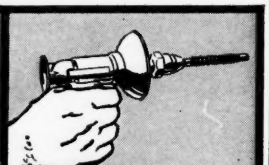
for condenser and heat exchanger tubes

Lightweight. Powerful. Air-driven. Trigger-action control with speed governor to prevent shaft-whip. High-speed motor reduced through planetary gears to 1500 rpm. Integral water-feeding attachment with finger-action valve which controls flow of cooling water into hollow shaft and drill or brush. Built-in oil reservoir. Send for tube cleaner bulletin Y-48.

DRILLS AND BRUSHES FOR VARIED NEEDS
Brushes for light deposits. Four types of drills clean light, hard-heavy, hard-light, and gummy deposits.



SUSPENSION TYPE
Air, steam or electric heavy-duty motor, for removing hard, heavy deposits. Ball bearings absorb thrust in either direction.



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For extra-fast cleaning of light deposits in tubes ½ in. to 1¼ in. Air or water pressure shoots nylon brushes or rubber plugs through tubes.

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V1-9

tuating beam. The valve body is self-draining.

The standard model is a two-way inline unit, but a three-way valve is available. Sized to 1 in., the unit is designed for low pressure drop, and minimum turbulence to minimize erosion of the valve trim. Various automatic operators may be used, or the valve may be manually operated.—**Valcor Engineering Corp., Kenilworth, N. J.** 161B

Plasma arc generator

Unit spheroidizes refractory particles of 100-150 micron size.

Refractory particles with melting points of 4-6,000 F. can be formed into spheres with a plasma arc generator. The process can facilitate production of filtering devices and free-flowing powders, and aid in material compaction and sintering.

In operation, powder is injected into a mixing chamber where particles are spheroidized by mixing with plasma gas streams generated by passing inert gas through an arc. The high-velocity mixture is water cooled, then particles are separated from effluent gas in a standard cyclone separator.

Principal advantages of the system: particles achieve optimum sphere shape from long residence time in the mixing chamber, and with only minor modifications the process can be used for combining and reacting various gases, liquids and solids.

Capacity is about 10 lb./hr. of powdered product.—**Plasmadyne Corp., Santa Ana, Calif.** 162A

Briefs

Fluorescent detector finds hairline cracks as well as straight-through leaks in aluminum, copper, plastics, stainless steel and other ferrous or nonferrous solids. Water-soluble materials employed are removed with a bath or rinse.—**U. S. Casting Repair Corp., Philadelphia.** 162B

Floating foam arrestor almost completely covers the surface of material in a mixing tank. Attached to the shaft of the mixer, it deflects material—forced to the surface—along the bottom of the mat and down the sides of the mixing tank. For mixers with capacities from 3 to 3,000 gal.—**Barrington Industries, Inc., Providence, R. I.** 163A

Thermocouple has stainless steel retaining nut that permits installation and disassembly without twisting a stainless steel braided cable. Said to be extremely accurate, and small sized to hold heat dissipation to a minimum, the unit may be ordered with any length cable.—**The Advanced Products Co., North Haven, Conn.** 163B

Ball valve of stainless steel contains Teflon seats that are machined to insure accurate mating between seat and ball surfaces, in the temperature range of –20 to +400 F. With buna-N seats, range is –20 to +220 F.—**The Lunkenheimer Co., Cincinnati.** 163C

Equipment Cost Indexes . . .

	Mar. 1961	June 1961
Industry		
Avg. of all	237.2	236.9
Process Industries		
Cement mfg.	231.3	230.9
Chemical	238.0	237.3
Clay products	224.8	224.4
Glass mfg.	224.7	224.0
Paint mfg.	229.7	229.4
Paper mfg.	229.3	228.6
Petroleum ind.	234.7	234.8
Rubber ind.	237.6	237.6
Process ind. avg.	235.9	235.2
Related Industries		
Elec. Power equip.	237.9	235.1
Mining, milling	239.4	238.7
Refrigerating	268.5	268.6
Steam power	224.9	225.0

Compiled quarterly by Marshall and Stevens, Los Angeles, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124-6 for method of obtaining index numbers; Mar. 6, 1961, pp. 115-116 for anual averages since 1913.

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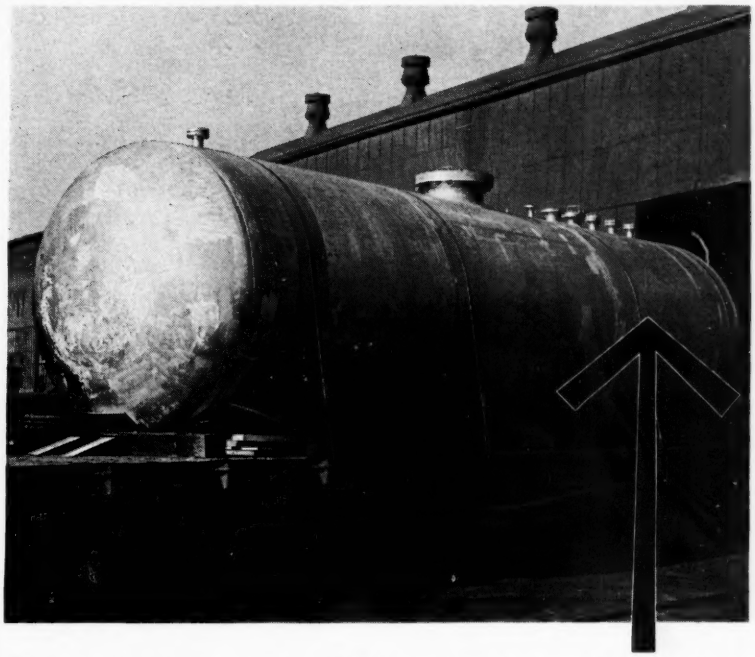

Graver tank for rocket fuel prevents contamination, reduces general maintenance

Built by Graver Tank & Mfg. Co., East Chicago, Ind., division of Union Tank Car Co., this aluminum pressure vessel stores rocket engine fuels for a famous eastern aerospace contractor. It was constructed for a design pressure of 45 psi, and was welded automatically. Aluminum prevents product contamination, resists corrosion, costs less to maintain. Whether product storage is an intermediate or final step in your operations, tanks of ALCOA® Aluminum will help cut costs and preserve product purity. Send the coupon for more information.

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- ☐ 68-10460 *Process Industries Applications of Alcoa Aluminum*

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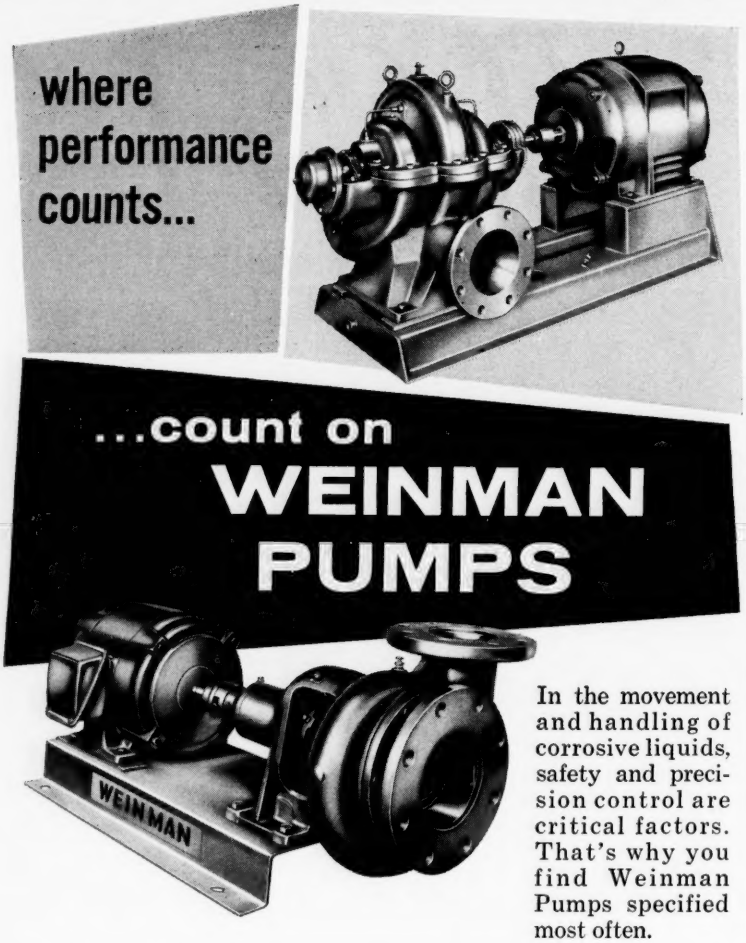

In the movement and handling of corrosive liquids, safety and precision control are critical factors. That's why you find Weinman Pumps specified most often.

A big favorite of the chemical industry is the job-proven, high-capacity Weinman Single Stage, End Suction Pump. And, it's pretty obvious why this is so. First . . . design simplicity and rugged construction for smooth operation and greater endurance. Second . . . dependability and versatility for functioning continuously on a wide variety of jobs. Third . . . precision-built and job-fitted for greater efficiency. Fourth . . . capacities up to 2000 g.p.m. against heads up to 260 feet. Fifth . . . economy . . . in initial cost, upkeep and long working life.

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Technical Bookshelf

PRESENT PRACTICE

GAS AND AIR COMPRESSION MACHINERY. BY L. F. SCHEEL. MCGRAW-HILL. 326 PAGES. $12.

Reviewed by Hunt Davis, Director of Engineering for Fluid Machinery, Harrison Div., Worthington Corp.

This is an extensive compilation, based on the author's wide experience with air and gas compressors and prime movers. As such, its flavor is that of a recounting of present practice, without a critical appraisal of the state of the art. Consequently, there are presentations in some areas that, while an accurate accounting of current practice, are arbitrary and incomplete in assumptions and premises.

The book will readily find its place in the reference library of the equipment engineer, for it ably discusses the selection and economic optimization of compressors and drivers. It is here that it best fills a need.

In the analytical and theoretical presentations, however, the author is less successful. For one example, it seems unfortunate to the reviewer that no more space was devoted to the thermodynamics of real (non-ideal) gases. The brief presentation hits the high spots, but suffers from the popular tendency toward inexact formation of definitions, leading to confusing semantics, if not conclusions.

In the reviewer's opinion, this book is for the operating engineer who wants the state of the art served up pronto, and never mind the shortcomings.

ENCYCLOPEDIC REFERENCE

COMPRESSED AIR AND GAS HANDBOOK. 3RD ED. COMPRESSED AIR AND GAS INSTITUTE, 122 E. 42ND ST., NEW YORK 17, N. Y. 570 PAGES. $8.

Also reviewed by Hunt Davis.

A very useful reference on most phases of application of industrial air and gas compressors, this handbook is particularly well compiled in the areas of pneumatic systems, air powered tools and rock drills.

The authors present the usual

fundamental (and oversimplified) thermodynamics, and typical operating characteristics of all types of compressors. Relative advantages and disadvantages of these are outlined, typical types of application are listed, and many excellent installation photographs are included.

A commendable job has been done in compiling definitions, test procedures and codes, along with numerous application, selection and installation aids, not only for compressors but also for compressed-air distribution system design.

The book should serve well as an encyclopedic reference on application of compressors (with considerable commentary in related areas).

EYE ON RESEARCH

THE ELECTRON MICROSCOPE. BY M. E. HAINE AND V. E. COSSLETT. INTERSCIENCE. 285 PAGES. $9.25.

Reviewed by Frederick Coulston, Sterling-Winthrop Research Institute, Rensselaer, New York.

Not designed as a textbook, this is rather a collection of lectures on important phases of the design and theoretical considerations necessary for an understanding of the electron microscope.

Obviously, the average person who uses an electron microscope is not interested in how one designs the lens to give the maximum magnification, or what mathematics is involved in determining spherical aberrations of lenses. However, it is important for the proper use of an electron microscope that the scientist be aware of how these and other problems are solved by the designers of such microscopes.

Chapter 3, "Theoretical limitations to resolving power," and Chapter 4, "Image contrast," should be very helpful to the practicing microscopist. Much important information for skillful manipulation of the electron microscope is contained in these chapters.

Chapter 10, "Specimen techniques and applications," is well done but will primarily be useful to the expert. The latest preparative methods of specimens particularly for the visualization of bacteria and viruses are presented. Unfortunately, much of the chapter

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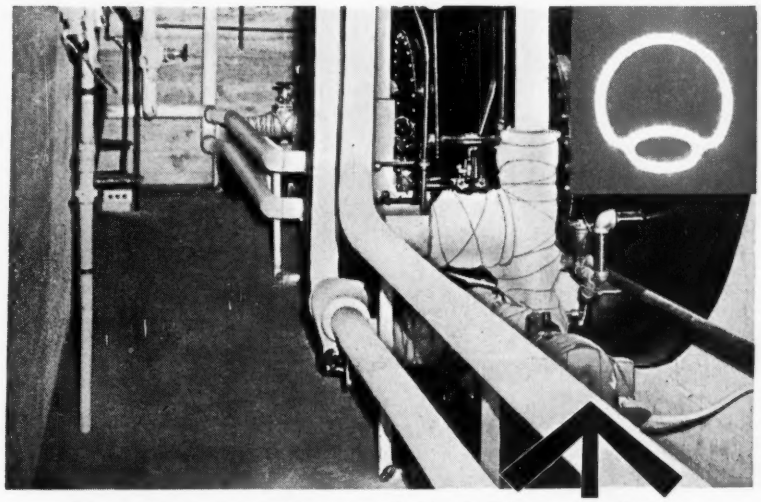

Globe Engineering installed Alcoa Unitrace system for piping paraffin and stearic acid . . . lowered fire hazard, increased production rate

Binney & Smith Inc., Winfield, Kansas, CRAYOLA® crayon manufacturer, recently effected cost savings with Alcoa* Unitrace piping, at one-eighth the quoted cost of stainless. Formerly, block paraffin had been melted slowly in holding pots. Now, Binney & Smith buys paraffin by tank carload, heats and pumps directly to underground storage. Stearic acid is also handled in the same system without discoloration. Fabricated and installed by Globe Engineering Co., Wichita, Kansas, the Unitrace system effected savings in purchasing, insurance, handling and production. Alcoa Unitrace is the light, strong, corrosion-resistant pipe that provides steam and product passages in a single extruded unit —eliminating costly external steam jackets or inefficient tracer tubes. Please send coupon for more information.

*Registered trademark of Aluminum Company of America

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- ☐ 34-10197 Aluminum Pipe and Fittings
- ☐ 34-10418 Alcoa Unitrace: Combines Piping and Tracing in One Unit
- ☐ DD-514 Alcoa Duotrace Technical Report
- ☐ 68-10460 Process Industries Applications of Alcoa Aluminum

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SLY TUBE-TYPE FILTER
Dust load was concentrated at certain points, causing premature tube failure.

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Three factors play a part in longer Dynaclone filter bag life — as proved on the most demanding applications. (1) Dynaclone construction and low air-velocity design insure even distribution of dust. (2) "Resist-O-Wear" bags have 3-section design for greater basic bag strength. (3) Dust is removed from bags by reverse cleaning air. No shaking — no abrasion.

There are other reasons why the "Roll-Clean" Dynaclone sets an unmatched performance pace. Flat bag design means 20 to 40% more cloth in a given space — greater capacity per cubic foot of filter. The Dynaclone is automatically self-cleaning. It operates continuously, provides constant uniform suction at dust sources for complete collection.

Check *all* the Dynaclone advantages . . . ***Send for 36-Page Catalog 104.***

"Roll-Clean" Dynaclone: Patents 2,867,209, 2,938,598. "Resist-O-Wear" Filter Bags: Patent 2,959,247.

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stresses the older literature, although there are some 1960 references.

In summary, this is a useful book for the expert electron microscopist. Physicists and engineers involved in the design and use of the electron microscope will find it most interesting. Well written, with many excellent diagrams and photographs, it should prove to be a valuable asset to any laboratory where the electron microscope is employed as a research tool. The book is indeed a good summary of "The Present State of the Art" to quote its subtitle.

In Rapid Review

The Chemical Formulary, Vol. XI. Ed. by Bennett. Chemical Publishing Co., New York. 416 pp. $8. Exactly like the preceeding ten volumes in this series, this book is a hodgepodge of recipes for chemical specialties. If you want to concoct a fly spray, an imitation mushroom flavor or a polyethylene adhesive, or if you have an urge to blacken "stainless" steel, Bennett will tell you how to do it. A list of suppliers of the (sometimes odd) ingredients called for is included.

And Also Received

Chemical Engineering Thesaurus. A 256-page "word reminder or word association list" for use in indexing, storing and retrieving information. Primary purpose is to provide a list of possible additional indexing terms for the engineer who indexes or abstracts technical documents, much in the same way that "Roget's Thesaurus" serves less-technical fields. Booklet was developed from a list originally prepared by the Engineering Dept. of Du Pont, which provided AIChE with the set of punched cards from which the final printout was made, duplicated and bound. $5 to AIChE members, $10 to nonmembers. Write: American Institute of Chemical Engineers, 25 W. 45 St., New York 36.

An Operations Research Study of the Dissemination and Use of Recorded Scientific Information. Published by stapling 36 multilithed sheets together, this Government Research Report (PB 171503) contains the results of a behavioral study carried out by Case Institute

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Experimental Nuclear Chemistry. By G. R. Choppin. Prentice-Hall. 226 pages. $9.25.

Progress in Industrial Microbiology. Vol. 3. Ed. by J. D. Hockenhull. Interscience. 230 pages. $8.50.

Physical Properties of Chemical Compounds—III. American Chemical Society, 1155 Sixteenth St. N.W., Wash. D. C. 489 pages. $6.50.

Proceedings of the Chemical Engineering Group. Vol. 39, 1958-59. Society of Chemical Industry, 14 Belgrave Square, London, S.D. 1. $5.

Physical Chemistry of Macromolecules. By C. Tanford. Wiley. 710 pages. $18.

The Language of Science. By W. Gilman. Harcourt, Brace & World, Inc. 248 pages. $4.95.

Introduction to Chemical Engineering. By L. B. Andersen and L. A. Wenzel. McGraw-Hill. 364 pages. $9.50.

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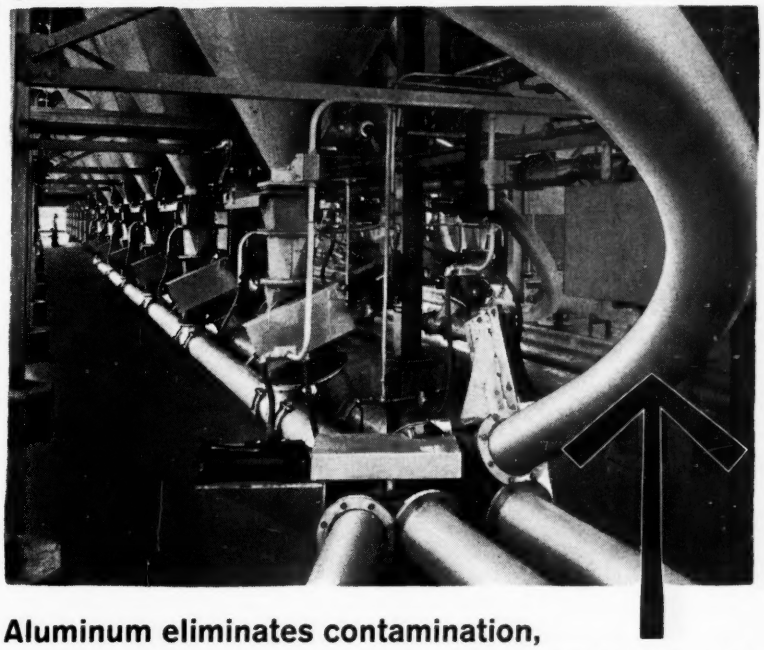

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Continued from page 7

lent of mine. It is clear that he and I arrive at the same answer to the problem. I certainly agree that this work energy received by the piston is stored as increased potential energy of the piston.

However, we differ in the interpretation of reversibility. A requirement for reversibility is that at every moment the driving potential causing the process to occur must be of differential size. An advantage of this simple definition is that it applies directly to noncyclical as well as to cyclical processes, and when dealing with noncyclical problems, such as this one, it is not necessary to invent a cyclical process to apply the test for reversibility. In terms of force units, the driving potential is the net upward force that is causing the piston to accelerate. In this problem, it is a finite quantity; therefore the process is irreversible.

In all real problems involving real gases and pistons with friction, Dr. Graff's definition of reversibility agrees with mine, because in order to keep friction negligible it would be necessary that the driving potential be infinitesimal in size.

Incidentally, an important deletion occurred in the statement of this problem, which I failed to notice when reading proof. It should have been stated that heat is supplied to maintain an isothermal expansion.

Also, it would have helped to note under Fig. 1 that the area of each piston face is 1 sq. ft.

M. R. CANNON
Cannon Instrument Co.
State College, Pa.

Con: Natural Graphite

Sir:

A news item in your Aug. 7 issue (p. 162) reports that General Graphite Co. of Ashland, Ala., is to supply National Carbon Co. with graphite for experimentation "in solid-fuel propellants at a $12-million Columbia, Tenn., laboratory."

We are at a loss to understand

the basis for such a report. General Graphite mines natural graphite. We manufacture fabricated graphite products of crystalline and structural properties especially adapted for high-temperature services. Natural graphite is not suitable for these products; our principal raw material is petroleum coke.

Our Advanced Materials Laboratory is at Lawrenceburg, Tenn., where, under the terms of a three-year, $12-million research and development contract awarded last year by the Air Force, we are developing advanced types of manufactured graphite for missile and space vehicle components.

W. A. STEINER
National Carbon Co.
New York, N. Y.

Con: The Real Culprit

Sir:

Although the experts analyzing Stardust Chemical Co.'s disaster (Aug. 7, pp. 111-24) have done an excellent job, one important factor seems to have been overlooked. While the origin of the fire was identified, nothing was said during the discussion about how to prevent a recurrence.

The fact that you ascribed the source of fuel to a leaking pump gland may indicate that you do not consider this type of failure as unusual. It is a rather common fault in process operations to accept, and for years tolerate, leaky packing as being inevitable and not worth worrying about. Maybe there is not sufficient appreciation of how costly packing troubles really are—acknowledging that this imaginary disaster is an extreme and perhaps exaggerated case.

Regardless of how a disaster starts, it should be axiomatic to eliminate the cause as quickly as possible. Otherwise, another one could occur before all safety precautions have been taken, and then even these may prove to be inadequate.

WALTER COOPEY
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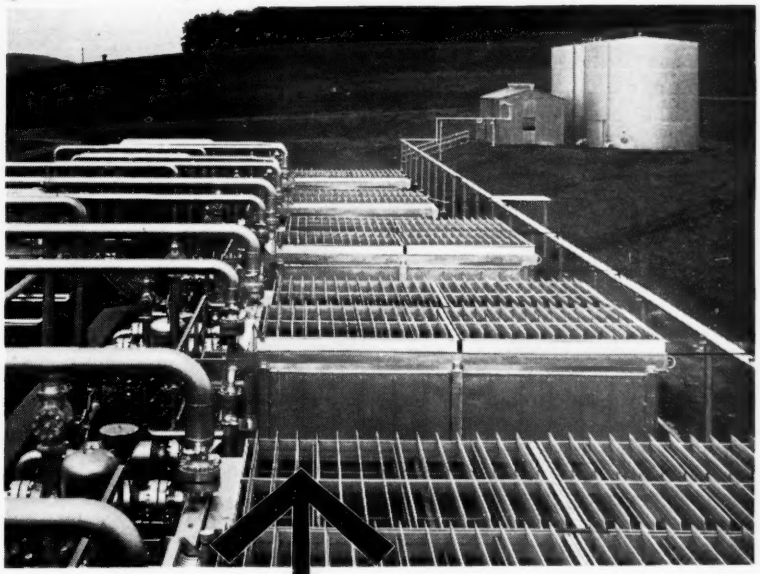

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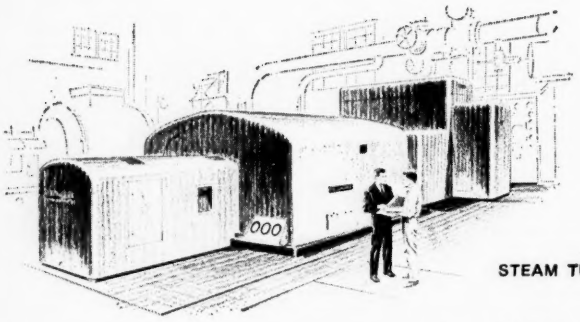

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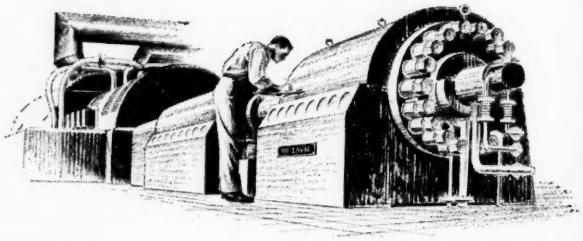

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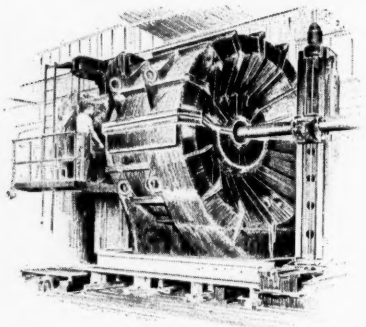

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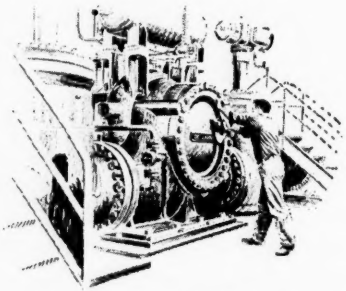

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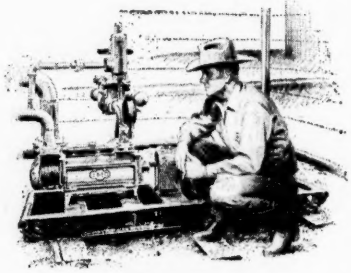

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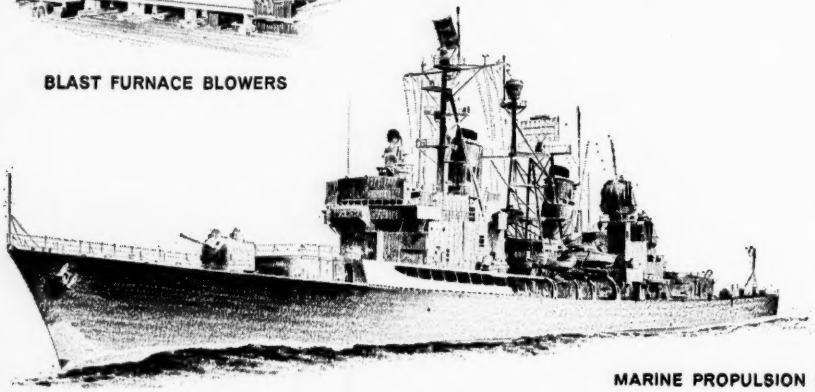

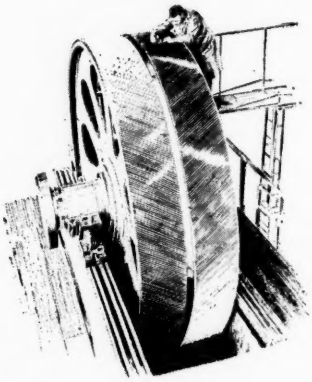

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EXPLORE

the advantages of

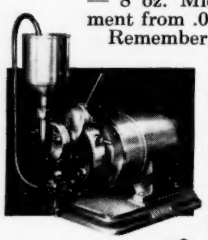
Gaulin Particle CONTROL

on your products

Find out for yourself how a Gaulin Homogenizer or Colloid Mill can improve your product and lower processing costs. You can rent one for only a few dollars a day.

Gaulin Laboratory Homogenizers — maximum capacity — 15 gph; minimum processable sample — 1 pint; pressure to 8,000 psi continuous; 10,000 psi intermittent.

Colloid RE Mill Model 2A — Capacity — 0-310 gph; minimum processable sample — 8 oz. Micrometer adjustment from .001 to .040.



Remember, the rental cost is applicable against the purchase price of the machines. Write for Laboratory Homogenizer Bulletin LH-55; RE Colloid Mill Bulletin — C-57.

Gaulin TRADE MARK

MANTON

Gaulin

MANUFACTURING CO., INC.

71 Garden St., Everett 49, Mass.

World's largest manufacturer of stainless steel reciprocating pumps, pressure exchange pumps, dispersers, homogenizers and colloid mills.

Manufacturers' Literature

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Chemicals

Acrylate Monomers.....Methyl Acrylate & Ethyl Acrylate are now available with only 15 ppm inhibitor. Grades containing 200 ppm inhibitor continue to be available. Lit.
119 *Rohm & Haas

Activated Carbon.....A complete line of activated carbons for every purpose; design & prefabricate complete purification, separation & recovery systems. Bulletin J-111.
R180 *Barnebey-Cheney

Alcohols.....Latest in the series is hexyl alcohol. Specifications on the full line of alcohols or other high quality chemicals is available on request.
67 *Enjay Chemical Co.

Aldehydes.....45-page booklet includes information on physical properties, constant-boiling mixtures, specification limits, test methods, storage, and toxicological properties.
174A Union Carbide Chemicals Co.

Algaecide..... Algae and fungus inhibitor composed of a mixture of chlorinated phenolic compounds for use in non-potable water systems described in literature.
174B Bird-Archer Co.

Alkyl Phenols.....Data sheets details physical properties, forms and suggested uses of developmental line of alkyl phenols and describes compatability with other materials.
174C Pitt-Consol Chemical Co.

Alkylated phenols.....General physical and chemical properties, structural formulas and major uses and applications given for four alkylated phenols in bulletin T-205.
174D Koppers Co., Inc.

Anti-Foams.....Economical solution of industrial foaming problems with the applications of minute quantities of silicone antifoam agents detailed in 8-page brochure.
174E Hodag Chemical Corp.

Antistatic Lubricants.....Information on two antistatic lubricants for woolens, worsteds and synthetics, including recommendations on applications, given in bulletin.
174F Emery Industries, Inc.

Aryl Mercaptans....Comprehensive 30-page booklet describes commercial and developmental line of chemical and covers applications, chemistry and physical properties.
174G Pitt-Consol Chemical Co.

Emulsifiers.....Research bulletin reviews line of emulsifiers with applications in the manufacture of soluble cutting oils, textile oils and emulsifiable solvent cleaners.
174H Sonneborn Chem. & Ref. Corp.

Filter Aids.....Over a dozen grades of highest quality filter aids are available. Details are contained in Bulletin 100 which may be had upon request.
189 *Industrial Filter & Pump Mfg. Co.

Filter Medium.....Anthrafilt will give filter runs approximately twice as long as sand or quartz. Rates up to 200 mgad are obtainable with less clogging.
BL190 *Anthracite Equipment Corp.

Fluorides.....for catalyst, reagent, intermediate, process applications. Technical information on all the various fluorides may be had upon request.
41 *Allied Chemical

Hydrocarbon Distillates....2-page bulletin on fully refined (food grade) light hydrocarbon distillates includes physical and chemical properties in tabular form.
174I Sonneborn Chem. & Ref. Corp.

Hydrolyzed Polyvinyl Alcohols.....Use of product in paper, adhesive and textile manufacture covered in first section of bulletin and physical properties described in second.
174J Air Reduction Chem. & Carbide

Lithium.....Technical data bulletin describes a commercial and experimental lithium for many uses. Unique properties are listed and suggested applications given.
174K Foote Mineral Co.

*From advertisement, this issue

Want to build up your files and keep them up-to-date? You can get any publication in this comprehensive guide — free — just for the asking.

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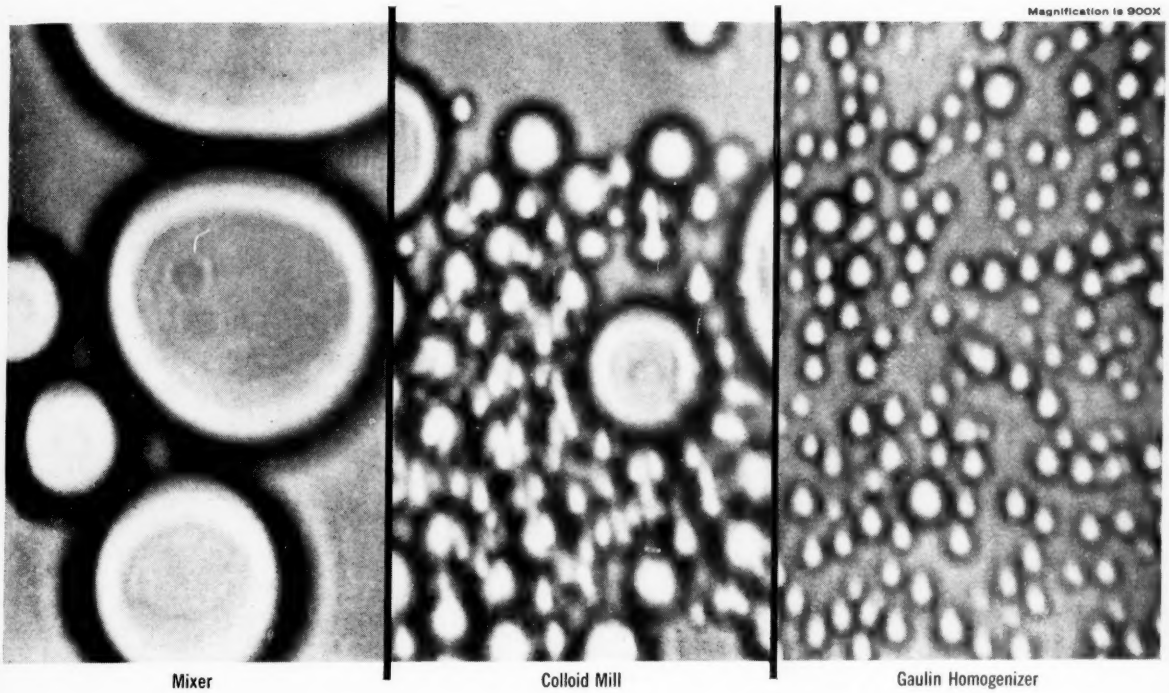
What's the Best Particle Size for Your Product?



Mixer | Colloid Mill | Gaulin Homogenizer

Gaulin Technical Assistance will give you the answers

You can make important changes in the chemical and physical properties of your product simply by controlling its particle size.

A slight size reduction in dispersing, emulsifying or blending will change everything from its color to its taste, the speed with which it chemically reacts, and almost every other property it has.

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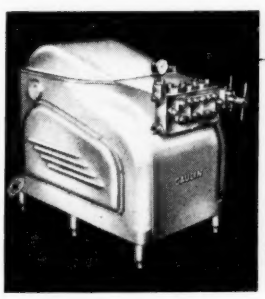
And since we manufacture a complete line of homogenizers, colloid mills and submicron dispersers, we can provide you with the best means for achieving the particle size you desire.

Gaulin Technical Assistance starts with the GTA Library of Product Information. Ask for special bulletins prepared on each type of equipment. Then call on Manton-Gaulin for our specialized Technical Assistance. There's no obligation.

See Chemical Engineering Catalog for address of your nearby Manton-Gaulin Representative.



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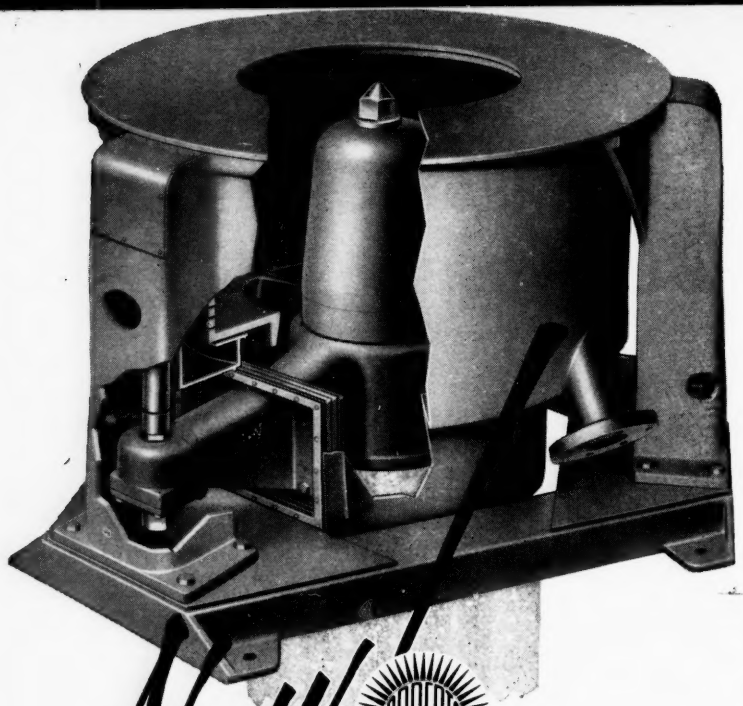

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Features . . . Link Suspension! No metal to metal moving parts. No lubrication. Soft lateral movement. No vertical movement. Effective damping. This suspension isolates dynamic parts from curb and foundation and reduces vibration to an astonishing low.

Features . . . Stationary Curb! With rigid feed, wash, effluent, and solids-discharge connections. No vibration damage to curb mounted accessories. Extends bearing life by reducing bearing loads. Increases personnel safety. Provides rapid drainage, more effluent capacity.

Features . . . Direct Coupled Hydraulic Motor! No belts. Compact. Light weight. Provides power for exclusive, slow speed, reverse discharging. Provides adjustable loading speed and adjustable top speed. Hydraulic braking (even at power failure). No brake linings to wear. Constant horsepower drive reduces peak electric loads.

Features . . . Oversize Anti-friction Bearings! Basket spindle bearing housing is air purged. This feature, designed to protect bearings from damaging effects of process material environment, also provides a convenient means for introducing controlled atmosphere within the basket. Can be grease lubricated while in operation. No-belt design — no belt-pull-loading on the bearings.

2905

Investigate its potential in relation to your operation. We will welcome the opportunity to co-operate with you.

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LITERATURE . . .

Lubricants.....Two bulletins, Nos. 461 and 242, discuss lubricants for extreme environmental conditions. One describes test results and the second is a data sheet.
176A Alpha-Molykote Corp.

Petrochemicals.....A complete line of aliphatic solvents as well as high purity naphthalene, benzene, toluene, xylene & other aromatics. Complete information.
71 *Ashland Oil & Refining Co.

Plasdone.....8-page brochure describes a pharmaceutical grade of polyvinylpyrrolidone which has been finding increasing applications in drug formulations.
176B Antara Chemicals

Plastics.....16-page Fact File, designed as a guide to those who buy plastics materials, describes properties and typical end uses of company's diversified line.
176C Monsanto Chemical Co.

Polystyrene.....In addition to a general description of each grade of polystyrene, catalog gives mechanical, physical, optical, thermal and electrical properties.
176D Solar Chemical Corp.

Polyvinyl Acetate.....Properties and uses of polyvinyl acetate plus specifications and physical characteristics of homopolymers and copolymers given in manual.
176E Shawinigan Resins Corp.

Processing Chemicals.....16-page catalog JWL-100 lists products and furnishes a brief description of each. End uses for principal applications are also described.
176F Nopco Chemical Co.

Resins and Urethane Foams.....8-page booklet answers the who, when, where and why of molding compounds, fire-retardant resins and urethane foams and includes properties and uses.
176G Durez Plastics Div.

Silicone Defoamers.....are best for banishing space-filling, time-eating foam in the processing of any foamer. A trial sample and full data are offered.
L181 *Dow Corning Corp.

Silicone Fluids.....20-page data book differentiates between available grades of silicone fluids, according to viscosity and classifies them by physical properties.
176H General Electric Co.

Solvents.....New technical bulletins are available on Pent-Oxone and Pent-Oxol solvents. Bul. A deals with physical properties & Bul. B deals with use in acrylic lacquers.
59 *Shell Chemical Co.

Construction Materials

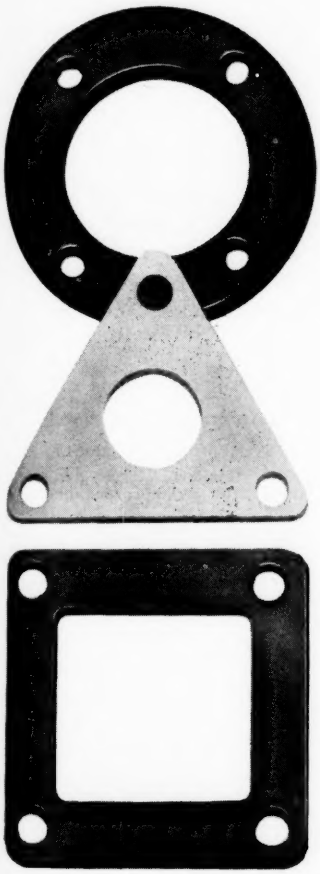
Aluminum.....A booklet entitled, "Process Industries Applications of Alcoa Aluminum" is available for information on the wide variety of applications of aluminum.
163d *Aluminum Co. of America

Aluminum Alloys.....A booklet giving information on resistance of aluminum alloys to weathering & to chemically contaminated atmospheres is available.
169a *Aluminum Co. of America

*From advertisement, this issue

WHY GASKETS OF ARMALON® HELP REDUCE MAINTENANCE COSTS

•they're long-lasting • resist harsh chemicals • withstand temperature extremes • cut replacement costs • reduce downtime



When you need new gaskets that must take all kinds of operational hazards in stride . . . be sure they're made of Du Pont "Armalon"* TFE-fluorocarbon felts impregnated with "Teflon"** resin.

These gaskets can take exposure to harsh chemicals at temperatures ranging from -320°F. to +550°F. and often wear up to 700% longer than those of ordinary materials. They've resisted 99.3% sulfuric acid at 200°C. for 18 months without default. In stainless-steel pipes carrying HNO_3 fumes at 170°C. and 97 psi, gaskets of this material have continued to function after 7 months!

Gaskets of "Armalon" are relatively soft, conform to uneven flanges with minimum pressures. A booklet containing more information about gaskets of "Armalon"... uses and case histories will be sent on request. Mail coupon today.

*"Armalon" is Du Pont's registered trademark for its TFE-fluorocarbon resin-impregnated felts
**"Teflon" is Du Pont's registered trademark for its TFE-fluorocarbon resins and fibers.

DU PONT INDUSTRIAL COATED FABRICS

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Fabrics Industrial Sales (1-10), Wilmington 98, Delaware
Please send literature on gaskets of "Armalon".

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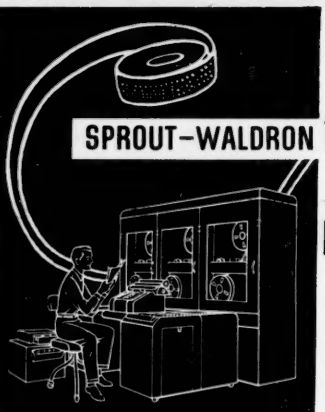
BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY



SPROUT-WALDRON PUTS DATA PROCESSING TO WORK TO SAVE YOU MONEY ON

PNEUMATIC CONVEYING SYSTEMS

75% to 80% of all pneumatic conveying needs are now standardized systems

The modern miracle of data processing has made it possible to analyze and tabulate Sprout-Waldron's long experience in air conveying systems to show that *75% to 80% of today's requirements can be handled by one of four standardized units!* Capacity data from years of specialized engineering and hundreds of successful pneumatic installations is now readily available.

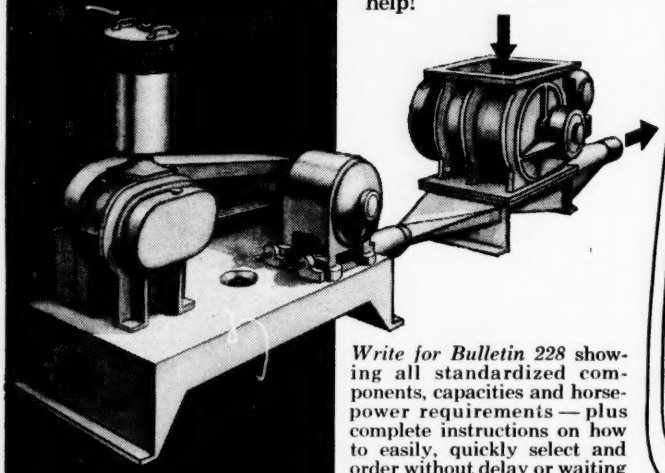
Data processing has enabled Sprout-Waldron to manufacture standard component parts in quantity and provide stock shipments — *with the savings passed on to you!* Now, most air handling requirements can be ordered without costly surveys or special engineering help!

4

STANDARDIZED EASY-TO-ORDER

PACKAGED AIR SYSTEMS

stocked for immediate shipment at BIG SAVINGS



Write for Bulletin 228 showing all standardized components, capacities and horsepower requirements — plus complete instructions on how to easily, quickly select and order without delay or waiting for outside assistance.

626

SW SINCE 1866

SPROUT, WALDRON & CO., INC.

MUNCY, PENNSYLVANIA

Size Reduction • Size Classification • Mixing & Blending • Bulk Materials Handling • Pelleting

LITERATURE . . .

Cement.....One-Cote insulating-finishing cement goes on in one coat to the desired thickness. Insulates, protects and finishes. Descriptive material is available.
6 *Eagle-Picher Company

Coating.....Plasite No. 7155 cold set coating will solve severe water corrosion problems. Field history and laboratory test results are available on request.
R186 *Wisconsin Protective Coating Corp.

Construction Material.....Fluoroflex is a specially processed Teflon construction material used for pipes, bellow & expansion joints, transfer hose, etc. Inform.
57 *Resistoflex Corp.

Gasket Material.....Booklet describes "Armalon" felts & includes data on characteristics, detailed list of specific applications & information on sizes & thicknesses.
177 *E. I. DuPont de Nemours

Nickel Coating.....Booklet describes Kanigen® process for depositing a uniform, hard, corrosion-and abrasion-resistant nickel alloy coating without the use of electricity.
178A General American Transportation Corp.

Packings.....Chempro Teflon suspensoid impregnated asbestos packings have the chemical resistance of Teflon plus the strength of high grade asbestos. Bulletin CP552.
L186 *Chemical & Power Products

Packings.....Super-Lon, White-Lon and Blue-Lon packings are available for chemical applications. The complete Chemical Brochure is available on request.
161 *A. W. Chesterton Co.

Packings.....New 5881 lattice braid packings resist strong acids at temperatures from 90 deg. F. to 500 deg. F. Information is contained in Catalog AD-185.
70 *Garlock, Inc.

Packings & Gaskets.....Chempac packings and gaskets seal better, last longer and resist chemicals and solvents. Further details are available on request.
32 *Johns-Manville

Platinum Metals.....in all shapes and forms . . . sheet, strip, foil, wire, tubing, gauze, salts & chemicals. Clads & Composites also available in many forms. Bulletin P-6.
65 *J. Bishop & Co.

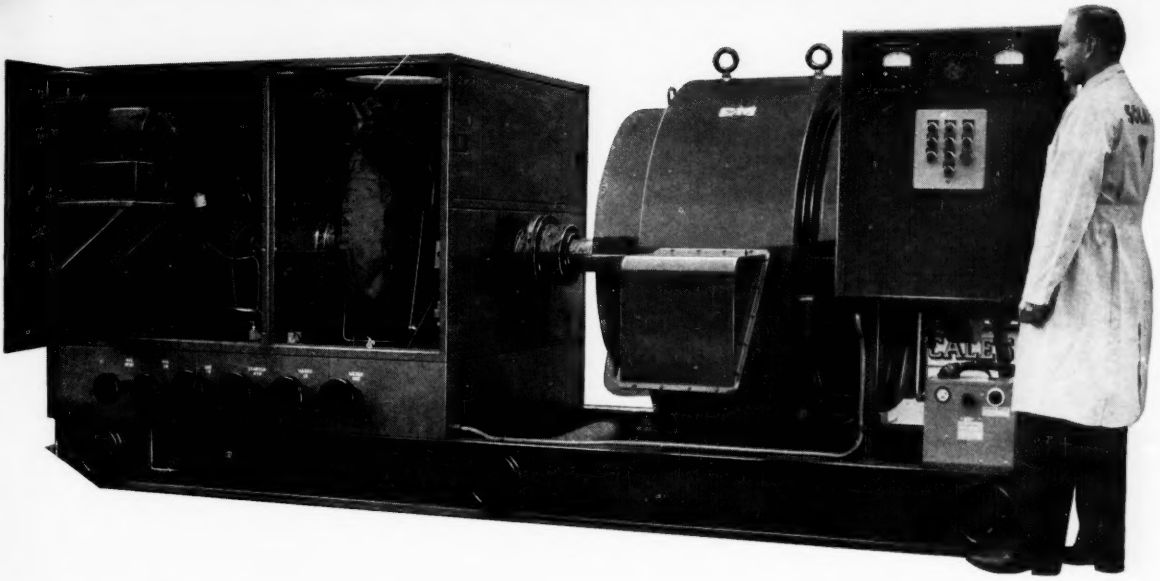
Protective Coating.....Properties and application techniques for Lyykold Fibrecoat, a weatherproof, mineral-armored asphalt, are described in 4-page bulletin.
178B American Bitumuls & Asphalt Co.

Roof Coating.....A new 65-page roofing manual, "Controlled Roofing Design and Maintenance" gives details on Roof Perm coating and is available on request.
26-27 *Lion Oil Co.

Stainless Steel.....Armco 17-4 PH stainless steel offers excellent corrosion resistance. More specific information is available to help you cut costs.
150-151 *Armco Steel Corp.

Stainless Steel.....Centrifugally cast stainless steel sleeves, liners, cored bar stock. All 13¼" long. 63 sizes ready to ship. Information on request.
R181 *The Vollrath Company

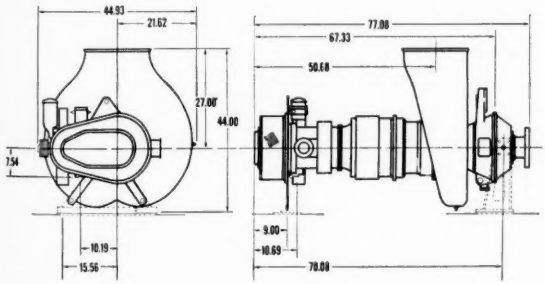
*From advertisement, this issue



800 KW!

Solar industrial gas turbine generator sets ideal for peak loading or constant duty

Versatile, compact industrial generator sets powered by Solar's T-1000 gas turbine engine have a nominal rating of 800 kw. They are ideal for either peak loading or constant duty electrical power applications. Simple design and rugged construction reduces maintenance



to a minimum. Installation is extremely simple. The engine is about 1/10th as heavy as diesel units of similar horsepower and occupies only 51 cu ft. No elaborate foundation or flooring base is required because the gas turbine is practically vibration-free.

Equipped with one of the several control systems available, the engine can be operated remotely and entirely automatically. It starts instantly and operates at full load without warmup, even after long periods of standby service.

Fuel economy of the Solar T-1000 engine is unmatched in its field. The engine runs equally well on a variety of fuels including gasoline, diesel fuel and natural gas. The exhaust may be used in a waste heat boiler or as combustion air in process apparatus or conventional boilers.

Cost of this gas turbine is competitive with diesel engines in many industrial applications. For further information on Solar's turbine-powered generator sets, its complete line of gas turbine engines or industrial compressors, write to Dept. J-151, Solar Aircraft Company, San Diego 12, California.

SOLAR

A subsidiary of International Harvester Company

The Rotating Seal That Solves Installation Problems

Unusual installation angles, worn machine connections, or the use of a wide variety of gases or fluids—none of these present problems to the Rotary Union. The unit automatically compensates for stress and strain and maintains a tight seal under the most adverse conditions, and each type will handle vacuum and most fluids and gases.

Rotary Unions are furnished with either right or left hand pipe threads in plain or syphon types. Special adaptors or fittings are supplied where needed and engineering service is available for O.E.M. applications.

There is a standard type and size Rotary Union for heating or cooling any revolving roll or drum. Pipe sizes ¼" through 5". Write for Bulletin 700 today.

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PERFECTING SERVICE COMPANY
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Baltimore—Buffalo—Camden, N. J.—Chicago—Cleveland
Los Angeles New York—Providence—Montreal—Toronto

LITERATURE . . .

Synthetic Rubber.....Reference booklet "Industrial Report on Viton Synthetic Rubber" contains heat and fluid resistance data and also physical and resistance properties.
121 *E. I. du Pont de Nemours & Co.

Titanium Fabrications.....Equipment fabricated from titanium plate, sheet and tubing is available for the chemical and missile industries to revolutionize many processes.
B149 *Standard Steel Corp.

Urethane Finishes.....Bulletin 59-C15 discusses polyurethanes that, because of their propensity to react with many familiar vehicles, are of interest to the coatings industry.
180A Mobay Chemical Co.

Wire Cloth.....Whatever metal or alloy needed in any size or quantity to the closest tolerances. High mesh counts are featured. A catalog is available.
51 *Cambridge Wire Cloth Co.

Electrical & Mechanical

Gas Turbine.....Information on turbine-powered generator sets, and a complete line of gas turbine engines or industrial compressors is available.
179 *Solar, Sub. of Internat. Harv.

High Voltage Components.....16-page catalog and applications manual covers complete line of components and equipment and provides information on anti-corona terminations.
180B Universal Voltronics Corp.

Panel Boards, Explosion-Proof.....A 28-page fully illustrated catalog, Bulletin **661 is available** for complete information of these explosion-proof panel boards.
1 *Appleton Electric Co.

Speed Drives.....Bulletin describes in detail basic components of drive, available in ratings from 50 through 2500 HP, gives theory of operation and control, and design features.
180C The Louis Allis Co.

Speed Variator.....New space-saving motorized speed variator assures constant H.P. and constant Torque loads. Engineering information in Bulletin 275.
63 *Cleveland Worm & Gear Div.

Handling & Packaging

Formula Capsules.....Technical bulletin contains information about Formula Capsules and Select-O-Weigh systems and how they can help your batching problem.
156 *Richardson Scale Co.

Molecular Sieves.....Bulletin lists all currently available chemical-loaded molecular sieves and gives information on compounds that can not be loaded on molecular sieves.
180D Linde Co.

Pneumatic Conveying Systems.....All standardized components, capacities & horsepower requirements are shown in Bulletin 228 which is available on request.
178 *Sprout, Waldron & Co., Inc.

*From advertisement, this issue

how to speed a reaction

Whether your working from C
and $C1_2$ to $COC1_2$, or NO_2 and
(air and water) to HNO_3 you
get it PDQ with an activated
bon catalyst. It's not sensitive
temperamental either. Give us
call and see how fast we

how to brighten the batch

For now we see through a glass
darkly . . . Whether your liqu
contaminants are dissolved or
loidal they darken the sales app
of your product. Granular or po
dered activated carbon decolor
ing will brighten the batch wh
nothing else will. You'll face cle
profits through the glass.

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We supply a complete line of ac
vated carbons for every purpos
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purification, separation, and
covery systems to meet your pa
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J-111 and recommendations o
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Most effective. Dow Corning silicone defoamers are best for banishing space-filling, time-eating foam in the processing of any foamer . . . from asphalt to beans to peas to zeins. Dow Corning Silicones start quicker, last longer. Eliminate messy and unsanitary foam-overs. Turn maintenance into production time.

Most efficient. Even the most violent foamers are tranquilized with a tiny amount of a Dow Corning silicone defoamer — often one part silicone solids per 10 million parts foamer is effective. For true economy, change to a Dow Corning antifoamer or defoamer. There's one just right for your product and system — oil, aqueous or food.

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first in silicones **Dow Corning**

LITERATURE . . .

Transportation Equipment.....Every unit is engineered to meet service requirements, including complete piping, metering and transfer equipment. Details.
4 *Pressed Steel Tank Co.

Heating & Cooling

Heat Control.....Equipment such as temperature-pressure regulators, float thermostatic steam traps, thermo-dynamic steam traps & pipeline strainers for heat control.
49 *Sarco Company, Inc.

Heat Exchangers.....U-tube heat exchangers having solid bronze baffles or tube supports as a standard feature described in 16-page bulletin that contains sizing information.
181A Killebrew Engineering Corp.

Heat Exchangers.....A unique feature of these exchangers is that the tube side can be cleaned while in operation. Bulletin HE-8 describes this unusual and standard equipment.
82 *Henry Vogt Machine Co.

Heat Transfer Equipment.....An illustrated brochure, personnel data sheet and customer references are available for information on the full line of heat transfer equipment.
B138 *Krueger Engineering & Mfg. Co.

Rotating Seal.....There is a standard type and size Rotary Union for heating & cooling any revolving roll or drum. Pipe sizes ¼" through 5". Bulletin 700.
L180 *Perfecting Service Co.

Temperature Control.....A complete line of pressure and temperature regulators is available. Detailed information on control applications is contained in Bulletin IV 1014.
45 *Spence Engineering Co., Inc.

Instruments & Controls

Analogger.....The MP-12 analogger combines continuous integrator with 3-15 psig square root extracting receiver. Literature is available for further information.
182a *Republic Flow Meters Co.

Coatings Gage.....New, non-destructive testing device developed for accurate gaging of non-conductive coatings on aluminum and its alloys described in brochure.
181B Twin City Testing Corp.

Digital Transducers.....offering true system compatibility, improved reliability and cost-saving simplification. Specifications and prices are available.
47 *Diginamics Corp.

Digital Voltmeter.....Complete details on the Kin-Tel 502B AC/DC digital voltmeter which offers highest accuracy, reliability, & dependability.
144 *KinTel Div., Cohu Electronics

Feeder.....Merchen feeder gives you greater feeding accuracy because of its sensitivity. It is compact & gives you hour-to-hour accuracy for feeding & blending. Inform.
159 *Wallace & Tiernan, Inc.

*From advertisement, this issue

63 SIZES
READY TO SHIP

centrifugally cast
Stainless Steel
SLEEVES • LINERS
CORED BAR STOCK

In a rush? Order from Vollrath for immediate **off-the-shelf shipment.** All 13¼" long, Semi-machined to 1/16" of sizes listed. Uniform quality.

TYPES 304 and 316

O.D.	I.D.	O.D.	I.D.	O.D.	I.D.
2½	x 2	4	x 2	4½	x 3½
2¾	x 2		x 2¼		x 3¾
	x 2¼		x 2½		x 4
3	x 2		x 2¾	4¾	x 2¼
	x 2¼		x 3		x 2½
	x 2½		x 3¼		x 2¾
3¼	x 2		x 3½		x 3
	x 2¼	4¼	x 2		x 3¼
	x 2½		x 2¼		x 3½
	x 2¾		x 2½		x 3¾
3½	x 2		x 2¾		x 4
	x 2¼		x 3		x 4¼
	x 2½		x 3¼	5	x 2½
	x 2¾		x 3½		x 2¾
	x 3		x 3¾		x 3
3¾	x 2	4½	x 2		x 3¼
	x 2¼		x 2¼		x 3½
	x 2½		x 2½		x 3¾
	x 2¾		x 2¾		x 4
	x 3		x 3		x 4¼
	x 3¼		x 3¼		x 4½

PHONE • WIRE • WRITE
the Vollrath Co.
FOUNDRY DIVISION
Dept. CE Sheboygan, Wis.

For sheet stainless steel items, drawn or spun, consult our Contract Sales Division.

ROCKWELL-REPUBLIC

MP-12 Analogger combines continuous integrator with 3-15 psig square root extracting receiver

Rockwell-Republic's MP-12 Analogger is a one-to-four pen, 12″ circular chart pneumatic receiver recorder. It offers a 3–15 psig square root extracting receiver and a continuous integrator, making it ideal for flow measurement.

The receiver converts a 3–15 psig differential pressure signal to a linear flow record. The integrator, based on Rockwell-Republic's time-proven watt-hour meter principle, catches swings and integrates all of the flow to provide an up-to-the-moment total.

INTERCHANGEABLE PLUG-IN RECEIVERS

The MP-12 Analogger's quadrant design permits a wide variety of recording and integrating combinations to meet your exact needs. For example, up to four completely unitized plug-in receivers may be quickly and easily installed for recording process variables. Or, Rockwell-Republic continuous integrators may be employed in either or both of the upper quadrants.

LIGHTWEIGHT AND COMPACT

Every aspect of the MP-12 Analogger's design from its aluminum case to its compact (requires only 15⅜″ x 17⅜″ of panel area) construction makes for efficient panel utilization. All connections are at the rear of the case.

ACCURATE CALIBRATION

The MP-12 Analogger's basic receivers are factory calibrated to within ±0.5% of chart range span. All adjustment points require only a screwdriver to make receiver output settings.

For more information about the MP-12 Analogger and other Rockwell-Republic instruments and controls, just mail the coupon. RF-27

REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
ROCKWELL

Please send latest literature on the following:

☐ MP-12 Analogger ☐ Process Transmitters ☐ Controllers
☐ VRC Ratio Computer ☐ Control Stations ☐ Recorders
☐ Control Valves ☐ Drive Units ☐ V-5 Gauges
☐ Desuperheating & Pressure Reducing Systems ☐ Flow Meters
☐ Electronic Control Systems ☐ Pneumatic Control Systems

Name _____ Title _____
Company _____
Address _____
City _____ Zone _____ State _____

Republic Flow Meters Co. *(Subsidiary of Rockwell Manufacturing Company)*
2240 Diversey Parkway, Chicago 47, Illinois

LITERATURE . . .

Gauges.....Deltadyne gauges for system pressures to 3,000 psi. Feature no moving seals; high-visibility scale. Literature is available on request.
R153c *Pall Corp.

Indicators.....The complete line of mv/v includes new indicators for use with any strain gage transducer system. Data sheets are available on request.
168 *Baldwin-Lima-Hamilton

Indicators.....Deltadyne indicators are available as either adjustable or non-adjustable. Red button pops to give visual indication of overpressure. Literature.
R153b *Pall Corp.

Instrumentation.....The full story on new PneumatiK Tel-O-Set instrumentation is contained in a booklet that covers in words & pictures all features.
24-25 *Minneapolis-Honeywell

Magnetic Flow Meter.....to help solve your sticky measuring problem. The meter with no flow restrictions. Details are contained in Bulletin 20-14.
29 *Foxboro Co.

Meters.....A 28-page technical bulletin, Meter Bulletin 566S lists liquids, helps pick proper sizes and features meters 2 to 2000 gpm. Available on request.
117a *Neptune Meter Company

Oxygen Analyzers.....for continuous oxygen measurement accuracy. A complete line is available for your particular needs. Details are contained in Data File 14-40-08.
81 *Beckman Instruments, Inc.

Programmer & Controller.....The Pre Korder is both a programmer & recording controller which brings new flexibility to the automation of industrial process.
L187 *Research, Inc.

Refractometer.....Bulletin describes instrument designed for applications where the liquid stream is dark and/or viscous or must be held at high temperatures or pressures.
182A Walters Assoc.

Switches.....Deltadyne switches are adjustable for signalling pressure and differential pressure from 0.25″ wc to 200 psi or psid. Literature is available.
R153a *Pall Corp.

Transmitter.....A pneumatic temperature transmitter with automatic compensation for ambient temperature and pressure changes described in bulletin 13-17C.
182B The Foxboro Co.

Transmitters.....are available complete with remote or in-place recorder. Further information on these instruments is contained in literature which is available.
R153d *Pall Corp.

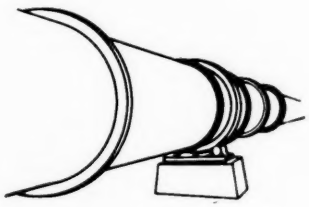
Transmitter.....New Mag-Pipe Magnetic Flowmeter Transmitter permits the use of miniature instruments to save panel space. Details are contained in Bulletin 98418.
22-23 *Taylor Instrument Co.

Viscometers.....Bulletins give details on the line of viscometers for control in blending, coating, cooking, diluting, dipping, extruding, fuel burning, etc.
182C Norcross Corporation

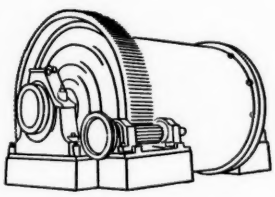
*From advertisement, this issue

TRAYLOR EQUIPMENT

for the mining and process industries

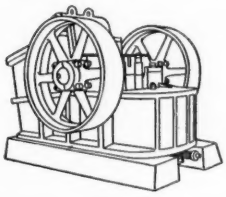


TRAYLOR ROTARY KILNS AND SLAKERS... the excellence of design and engineering of Traylor kilns is a result of over 58 years' experience in the manufacture of specialized machinery for the mining and process industries. Kiln shells are automatically welded of heavy steel plate. Alignment is maintained by easily adjusted supports. Full-floating type riding rings are of forged or cast steel, mounted on machined pads. Steel main gears and pinions are machined on a special gear generator. Kilns are designed and engineered to meet your specifications. Traylor has the most extensive research facility now available in the industry to insure delivery of process-perfected equipment to you.

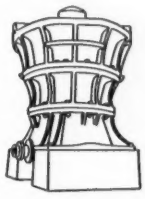


TRAYLOR BALL AND COMPARTMENT MILLS ... **BALL MILLS** in both overflow and diaphragm discharge types have shells of welded steel with detachable heads of cast steel.

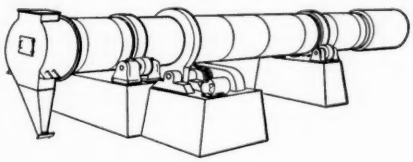
COMPARTMENT MILLS... partitioned by slotted diaphragms, these mills allow progressive reduction of products as it passes through different grades of grinding media within the mill, thereby reducing the amount of handling necessary in product reduction.



TRAYLOR JAW CRUSHERS . . . feature the original curved jaw plates for greater capacities at finer settings and longer life of the wearing plates. The swing jaw is made of cast steel of extra heavy design and the pitman shaft is of annealed open hearth forged steel, for lightness with great strength. Maintainence and inspection are simplified by the design which makes all parts readily accessible.



TRAYLOR GYRATORY CRUSHERS . . . Traylor is world famous as the manufacturer of giant 60″ gyratory crushers, secondary reduction crushers and fine reduction crushers. Crushers are designed with Traylor's original non-choking, self-tightening bell heads and curved concaves for large tonnage of small product and uniform size with a low percentage of waste and fines. Power applied as a direct crushing force offers greatly reduced power requirements at every setting.



TRAYLOR COOLERS... manufactured in diaphragm and multiple tube design, receive the same care in design and construction as Traylor kilns.

TRAYLOR SLURRY FEEDERS AND TABLE FEEDERS... **SLURRY FEEDERS** are self contained, fully closed ferris wheel type feeders . . . accurately supply a constant volume of slurry to kilns and mills. Single welded tank and hopper units are available in sizes from 36″ to 84″.

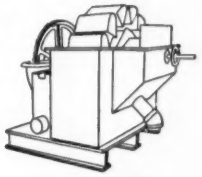
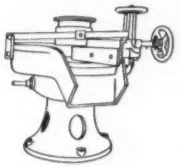


TABLE FEEDERS . . . accurately regulate the flow of material to mills, kilns and dryers. The revolving table receives material at its center from an adjustable feed spout. Feeders available from 2′ to 10′ in diameter.



See Chemical Engineering Catalog for details and specifications.

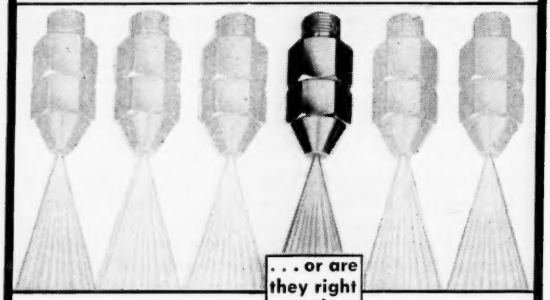
TRAYLOR ENGINEERING & MANUFACTURING

DIVISION OF FULLER COMPANY

1551 **MILL STREET • ALLENTOWN 1, PA.**

4172
TGA-3

Are the **SPRAY NOZZLES** you use in the grey zones...

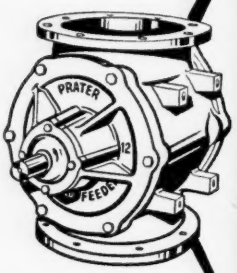


Like an electronic system, a spray nozzle system can be *tuned* for maximum performance. To do this select spray nozzles that *exactly* fit the system needs . . . in terms of capacity, spray characteristics and materials. The use of Spraying Systems spray nozzles keeps spraying installations out of the costly grey zones. The reason: you have a choice of over 12,000 *standard* nozzle types and capacities to match the nozzles exactly to your need.

FOR PROOF . . . write for Catalog No. 24.

SPRAYING SYSTEMS CO.
3275 Randolph St. • Bellwood, Ill.

PRATER ROTARY AIRLOCKS



SEND YOUR AIRLOCK FEEDER PROBLEMS TO PRATER

Prater foremost builders of airlock feeders

PRATER PULVERIZER COMPANY
1517 South 55th Court • Chicago 50, Illinois

LITERATURE . . .

Pipes, Fittings & Valves

Alminum Pipe & Fittings.....A booklet describing aluminum pipe and fittings and their various applications and dimensions is available on request.
163a *Aluminum Co. of America

Ball Valve.....New stainless steel ball valve gives precision performance in corrosive service. Details are contained in Circular 612 which is available.
53 *The Lunkenheimer Co.

Ball Valves.....feature rubber seats that seal tight and stay tight through all conditions, Teflon stem packing to reduce wear. Complete details are offered.
31 *Rockwood Sprinkler Co.

Ball Valves.....Bulletin No. 1 gives design characteristics, a parts list and information on applications of List 26 ball valves and is available on request.
184A Willamette Iron & Steel Co.

Bi-Valves.....give globe valve performance at gate valve prices. Guarantee automatic self-seating & positive shutoff. Further details are offered.
61 *Chapman Valve Co.

Butterfly Valves.....feature drop-tight shutoff, maximum seat life and easy operation. Complete information is contained in Bulletin 5904 which is offered.
137 *Darling Valve & Mfg. Co.

Compression Tube Fittings.....20-page catalog illustrates, describes and gives dimensions of 25 tube fittings manufactured in both type 316 stainless steel and brass.
184B Parker-Hannifin Corp.

Control Valves.....Catalog B-I is available for complete data on these versatile valves for positive control of your problem fluids.
T188 *G. W. Dahl Co.

Fibercast Pipe.....A centrifugally cast, thermostat epoxy resin, glass fiber reinforced pipe developed to handle pressure and corrosion problems discussed in literature.
184C Fibercast Co.

Gate Valves.....Flanged 150 & 300-lb. steel gate valves have been added to the 3600 Series. Available in sizes ½" to 2", suitable for all services at temperatures to 1000F.
127 *Crane Co.

Pipe.....Bondstrand plastic pipe is made of tension-wound glass filaments impregnated with resin. Complete information is available in bulletin on physical & design data.
135 *Amercoat Corp.

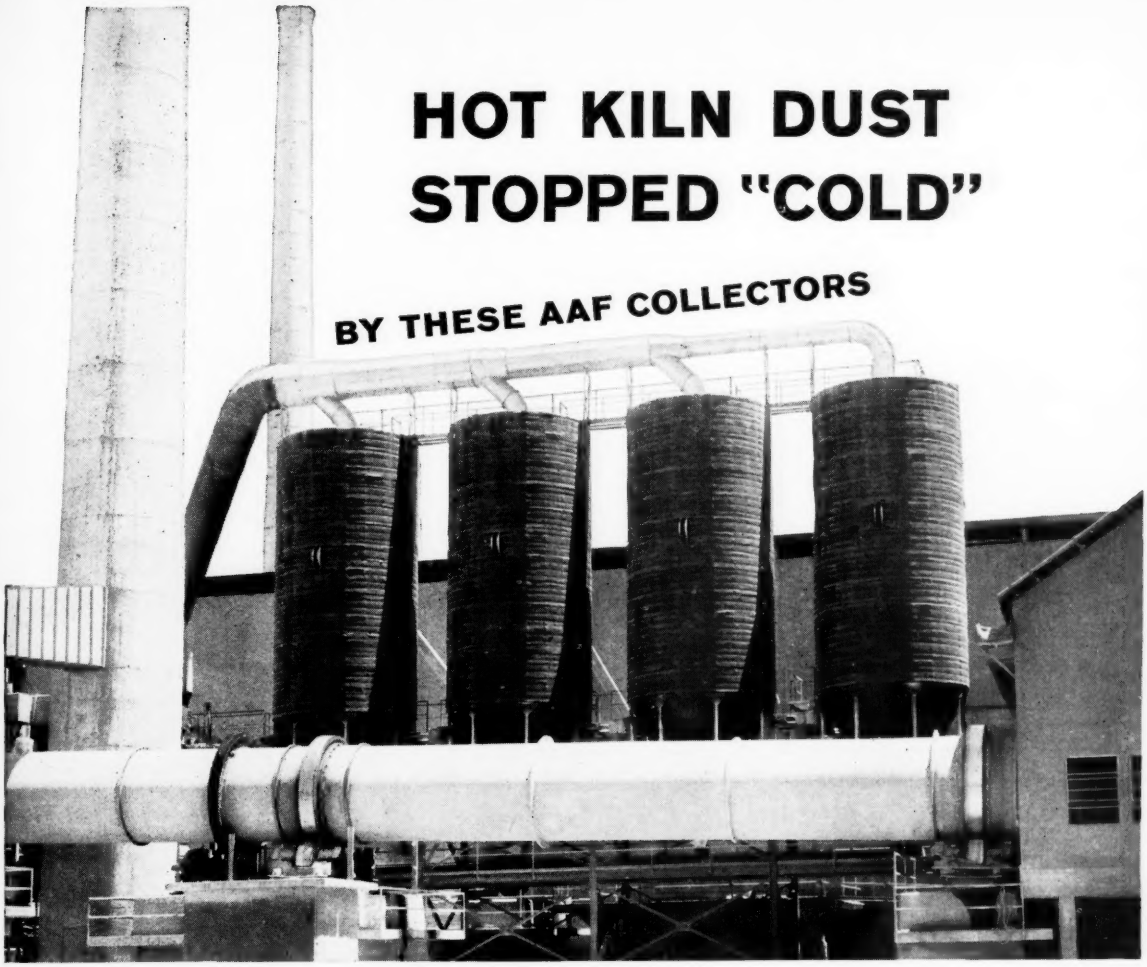
Pipe Product.....A technical report on Duotrace, a product which contains two trace passages & a product passage integrally extruded in a single pipe is offered.
163c *Aluminum Co. of America

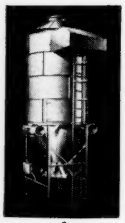
Piping & Tracing.....A bulletin describing Unitrace which combines piping and tracing in one unit is offered and may be had upon request.
163b *Aluminum Co. of America

*From advertisement, this issue

HOT KILN DUST STOPPED "COLD"

BY THESE AAF COLLECTORS





AAF AMERtherm units collect cement kiln dust at 450°F

AAF dust collectors at this cement plant are really in a hot spot. Here, four AMERtherm glass cloth units are exhausting 47,000 cfm of dust-filled air from the cement kiln at temperatures up to 450°F — far above the 200°F limits of standard fabric dust arresters.

AAF's new AMERtherm is designed for continuous operation up to 550° F which will take care of most high temperature dust problems. Glass cloth bags permit continuous high-temperature, high-efficiency operation in the collection of extremely fine dust or dust which must be reclaimed dry. Little maintenance is ever needed. Even bag replacement is quick and simple.

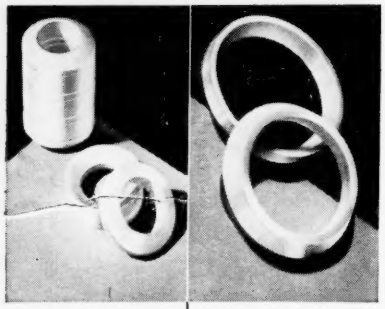
Elsewhere at this cement plant AAF is handling other types of dust problems. Dust produced from barge unloading and at transfer points is stopped by five AAF AMERjet fabric collectors. These units collect sub-micron particles dry for reclaiming, returning only clean air to the atmosphere.

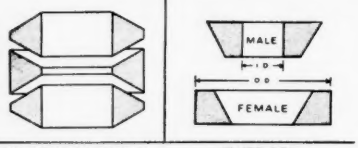
If you have a dust problem, talk with the *one* company that makes *all kinds* of dust control equipment. For complete information on AAF's AMERtherm call your local American Air Filter representative, or write direct for Bulletin 283. Ask for Bulletin 279 for all the facts on the AMERjet. Address: Robert Moore, American Air Filter Company, Inc., 326 Central Avenue, Louisville, Kentucky.

AAF American Air Filter

BETTER AIR IS OUR BUSINESS

NEW CHEMPRO
LOW GLAND PRESSURE
TFE TEFLON†
PACKING SETS





"CUP AND CONE" "WEDGE"

USED FOR VALVES, HEAT EXCHANGERS AND OTHER STATIC AND SEMI-STATIC APPLICATIONS

Chempro Style 300 "Cup & Cone" and Style 305 "Wedge" packing ring sets are two new resilient, low gland pressure packings designed for tight, sure sealing with a minimum gland pressure. Nominal gland pressure causes the rings to slide against each other, exerting pressure both against the stem or rod and the bore.

These packings have all the advantages of Teflon, being completely unaffected by the strongest acids, solvents and alkalies.

COMBINATION SETS AVAILABLE FOR ROTATING SERVICE

Resilient Chempro "Cup & Cone" or "Wedge" rings can be combined with tough, pressure-resisting Chempro Style 101 packing rings to form a rugged combination set ideal for use on a wide range of rotating or reciprocating services.

Write for revised Chempro Bulletin CP-552, giving complete ordering information.

† duPont trademark

CHEMICAL & POWER PRODUCTS, Inc.

5 Broadway, New York 4, N. Y.

LITERATURE . . .

Spray Nozzles.....in a great variety of sizes and types. Catalog 24, a forty-eight page reference manual is available and may be had upon request.
T184 *Spraying Systems Co.

Stainless Steel Hose....Flexible stainless steel hose is being used to convey steam, hot water, fuels, cyrogenic fluids, air, gas, liquids, corrosives, etc. Inform.
55 *Anaconda Metal Hose

Tubing, Heat Exchanger.....offers high quality at lower cost. Information on welded steel and stainless steel heat exchanger tubing is contained in Brochure No. 5.
203 *The Standard Tube Co.

Valve.....Sampling valves assure perfect sealing by two compressible replaceable Teflon rings. A new catalog page is available for further information.
T157 *Strahman Valves, Inc.

Valves, Safety-Relief.....Complete information is provided in Catalog FE-118, covering both selection & sizing of Farris process Safety Relief Valves.
148 *Farris Engineering Corp.

Process Equipment

Centrifugal Separator.....assembled as a package unit. To process slurries difficult to dewater. Details are contained in Brochure 961 which is available.
B188 *Heyl & Patterson, Inc.

Centrifugal Systems.....effect accurate, continuous and controlled separation required in the manufacture of a wide range of products. A complete line.
10-11 *The Sharples Corp.

Centrifugals.....The Roberts LS/SC provides a combination of features. No metal to metal moving parts, rigid feed, wash, effluent, and solids-discharge connections.
176 *The Western States Machine Co.

Distillation Equipment.....8-page brochure discusses distillation equipment for the process industries and reviews the use and design of three principal types of trays.
186A Struthers Wells Corp.

Dry Processing Equipment.....Bulletin discusses line of separators, blenders and mixers, crushing and milling machines etc. with diagrams, illustrations and specifications.
186B Sturtevant Mill Co.

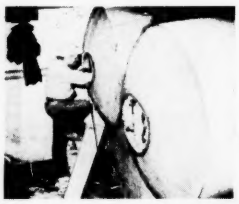
Dust Collector.....Because it has no moving parts-internally or in the gas stream- the Mikro-Pulsaire has proved ideally suited to handling abrasive materials.
129 *Mikro-Products

Dust Collectors.....Bulletin 283 is offered for details on Amertherm collectors for high temperature dust problems while Bulletin 279 contains facts on Amerjets.
185 *American Air Filter Co.

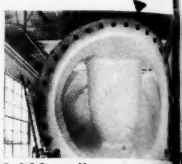
Dust Control.....Number of effective methods for controlling industrial dust and fumes described in bulletin that lists essentials of a typical dust control system.
186C Pangborn Corp.

*From advertisement, this issue

Only
PLASITE



Hot water tank lined with PLASITE No. 7155 cold set coating.



Inside of a 12 ton water pump capable of pumping 33,000 gallons per minute. Interior coated with PLASITE No. 7155, applied by Industrial Sandblasting Inc., Bedford, Ohio

••• WILL SOLVE SEVERE WATER CORROSION PROBLEMS

- High temperature high purity water tanks
- Hot water storage tanks
- Water boxes
- Hot water generators
- Condensate receivers
- Water treating tanks
- Structural steel in contact with vapors
- Concrete tanks and sumps
- Prevention of contamination and other water problems
- Fans and ducts

PLASITE 7155 is formulated for elevated temperature water service . . . to solve water corrosion problems for processing equipment as indicated above. In several installations after six years service in elevated temperature high purity water at 200° F. the tanks are still giving service and appear to be as good as when the coating was applied . . . the hot water generator illustrated above in the University of Wisconsin is in excellent condition after six years of continuous service. PLASITE 7155 is definitely a high resistant protective coating formulated with particular attention to water resistance.

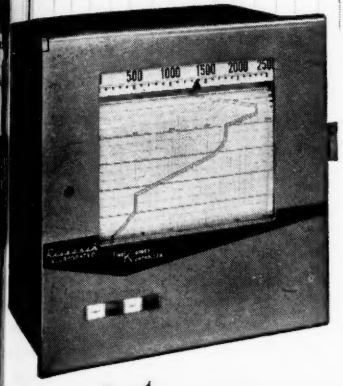
For Field History and Laboratory Test Results on Your Specific Problems WRITE . . .

wisconsin protective coating corp
GREEN BAY, WIS.
REPRESENTED IN PRINCIPAL INDUSTRIAL AREAS

Both a
PROGRAMMER
guided by a pencil-drawn curve

NO CAMS

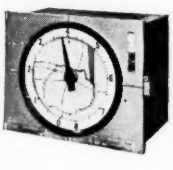
and a
RECORDING CONTROLLER
which superimposes a record of actual process performance and applies corrective control when performance deviates from the plotted program



PREKORDER TRADE-MARK

brings new flexibility to the automation of industrial process with closed-loop control.

1. **Pencil Programming** — No cams to cut.
2. **Superimposed Recording** — PreKorder's permanent record of process performance on a program chart overlay permits continuous visual comparison of record and chart.
3. **Programmed Limits**—To trigger alarm or shut-down circuits in case of process malfunction, just pencil allowable operating limits on the recording chart.
4. **Programmed Gain**—Varying the space between pencilled program lines varies the proportional control band or system gain.



Typical PreKorder applications are in programming temperature, pressure, power, load, flow, position, and other process variables. Both round and strip-chart models are available.

RI RESEARCH INCORPORATED

P.O. Box 6164G, Minneapolis 24, Minn.

LITERATURE . . .

Dust Filters.....The Dynaclone operates continuously & provides 20 to 40% more cloth. Automatically self-cleaning by reverse air. The 36-page Catalog 104 is offered.
172 *The W. W. Sly Mfg. Co.

Entrainment Separators....“Karbate” impervious graphite type MV offer complete corrosion resistance . . . low pressure drop, etc. Details in Catalog Section S-6900.
113 *Nat’l Carbon Co.

Ejectors.....Standard ejectors are available in sizes up to 3-in. maximum suction for fast delivery. They are simple, dependable and low-cost vacuum-producing devices.
B201 *Elliott Company

Floats.....Industrial floats feature corrosion resistance, extreme strength, buoyancy and dependability. A complete bulletin is available on styles, sizes, etc.
TL190 *Chicago Float Works

Glass Processing Units.....can be designed for your from QVF components made of borosilicate glass. Information on the possibilities, advantages & economy is offered.
12-13 *Corning Glass Works

Homogenizers & Mills.....Laboratory Homogenizer Bulletin LH-55 is offered along with RE Colloid Mill Bulletin C-57 for complete information on this equipment.
174 *Manton Gaulin Mfg. Co.

Hydrogen Sulfide Units.....solve the need for hydrogen sulfide gas in quantities not practical to handle by cylinders. Full information on these compact units is offered.
69 *Girdler Corp.

Liquid & Gas Processing.....16-page buyers guide containing concise engineering data deals with both corrosion resistant and water and waste treatment equipment.
187A Pfaudler Permutit Inc.

Mixers.....Turbo-Mixers for a wide range of mixing applications. Descriptive details on these mixers are contained in Bulletins T-11 and T-1159 which are offered.
75 *General American Transp. Corp.

Mixers.....The new Hi-Flo Lightnin mixers are made in a full range of sizes up to 50 hp. Details are contained in Bulletin B-526 which is available.
206 *Mixing Equipment Co.

Mixers.....A full line of Flomix, side drive, tank top, portable and tripod mixers are available. Additional information on all types in Bulletin 531A.
139 *Nettco Corp.

Process Centrifuges.....in a variety of types for your particular problem. Operation of these units opens new versatile possibilities in processing. Technical literature.
20-21a *De Laval Separator Co.

Process Equipment.....Bulletin 443 is available on request for detailed information on the full line of equipment such as conveyor dryers, spray dryers, etc.
79 *Proctor & Schwartz, Inc.

Process Equipment.....A complete line of equipment for the process industries including rotary kilns & slakers, ball & compartment mills, crushers, feeders, etc.
183 *Traylor Engrg. & Mfg. Co.

*From advertisement, this issue

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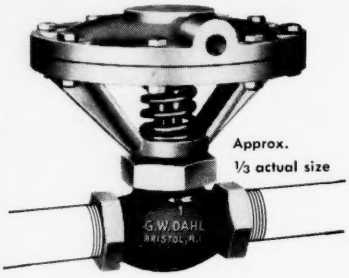

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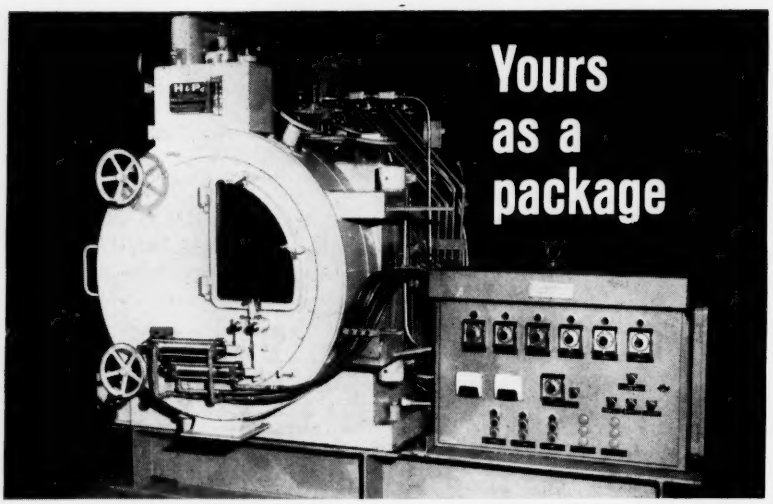

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LITERATURE . . .

Rotary Vacuum Dryer.....is designed for quick, completely uniform and economical low-temperature drying of materials that may be turned over while drying.
30 *J. P. Devine Mfg. Co.

Scrubbers.....S-F Venturi scrubbers for air pollution control and for solids recovery from kiln gases. Has no nozzles, trays or jets to plug. Information.
125 *Chemical Construction Corp.

Scrubber.....The Oriclone scrubber is a new type of high energy scrubber that is small and more economical than other units. Details are contained in Bulletin W-8560.
39 *The Ducon Company

Separator.....Crystals, powders, pellets or lumps are kept hopping as they pass through the screens of the Syncro-Matic separator. Technical literature is available.
20-21b *DeLaval Separator Co.

Solids-Processor....adds vacuum drying to liquid-solids blending. Systems completely packaged. In standardized models with charge capacities from 1 to 50 cu. ft.
36-37 *Patterson Kelly

Vacuum Dryers.....designed to meet your specific needs. A new booklet, "Handy Guide to Vacuum Dryer Selection" has been prepared & is available on request.
18-19 *F. J. Stokes Corp.

Pumps, Fans & Compressors

Acid Pump, Steam Jacketed.....guarantees trouble-free, low cost pumping of solutions which thicken or solidify above ambient temperatures. Details are available.
205 *A. R. Wilfley & Sons, Inc.

Blowers.....for metered, oil-free air and gas handling. Series 3200 for large capacity air requirements. Further information is contained in Bulletin S-59-I.
L152 *Sutorbilt Corp.

Centrifugal Pumps.....Bulletin 301 contains performance curves and technical data on pump designed to handle most corrosive solutions from $AlCl_3$ to $ZnSO_4$.
188A Industrial Filter & Pump

Compressor.....“Compressor Evaluation Guide” points out the six key areas of judgment required for compressor evaluation and details them in full.
Cover *Worthington Corporation

Compressor, Piston.....Non-lubricated ringless piston compressor assures absolute contamination-free compression of dry or moist gases. Information, specifications.
160 *Sulzer Bros. Inc.

Metering Pump.....Pulsafeeder metering pump offers precision metering at flow rates of from a few drops to 15.7 gal. per minute. Complete details in Catalog 59.
143 *Lapp Insulator Co.

Process Pumps.....Information on bearing life expectancy, shaft deflection, interchangeability charts and diagrams plus performance, application and dimension data given in bulletin.
188B Goulds Pumps, Inc.

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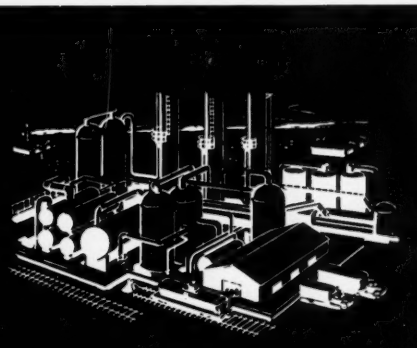

Chemical Processing

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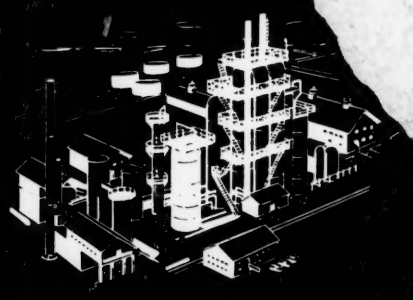
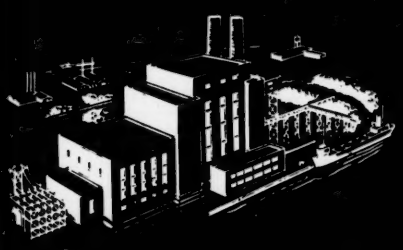
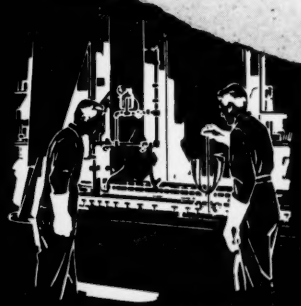


Refineries

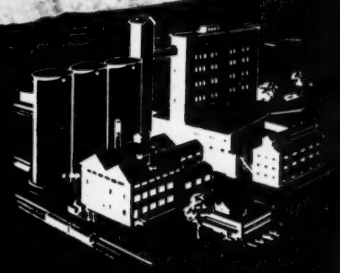


Power Plants



Electroplating

Heat Treating



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LITERATURE . . .

Pump.....Series 100 pump gives accurate metering with smooth control. Dependable, trouble-free, double capacity or two-liquid metering. Information is offered.
158 *Wallace & Tiernan, Inc.

Pump-Compressor Selector.....Slide rule selector gives suggested company air pump model when required air flow is set on scale plus data on motor h.p. requirements.
190A Gast Mfg. Corp.

Pumps.....New Can-O-Matic pumps with self-adjusting bearings are leak-proof. Information and specifications are contained in Advance Bulletin 977 which is offered.
72 *Buffalo Forge Co., Pumps Div.

Pumps.....For handling liquids, for heating, cooling and processing, a complete line of pumps is available. Feature simple design & rugged construction.
164 *The Weinman Pump Mfg. Co.

Rotary Pumps.....for your unusual liquid pumping problem. A 36-page Engineering Manual is available for details on these pumps and may be had upon request. Cat. KC.
B200 *Viking Pump Company

Services & Miscellaneous

Acid Neutralization.....Automatic and continuous acid neutralization of industrial waste water described in 16-page report that supplies tables and flow charts.
190B B-I-F Industries

Cost Engineering.....“Low First-Cost v. Low Ultimate Cost” is the subject of Booklet E-4 which is available as another in the series prepared for engineers.
L153 *Western Supply Co.

Cryogenics.....Reference card includes data on 11 physical properties of 31 cryogenic fluids in both engineering and metric units and includes a table of conversion factors.
190C Cryogenic Engineering Co.

Laboratory Machines.....Bulletin 067 gives a full description of all laboratory machines. Design provides easy access for cleanouts. Returns complete sample.
R152 *Sturtevant Mill Co.

Laboratory Supplies.....40-page catalog illustrates and describes over 300 products from apparatus to protective garments and contains a thermoplastic properties chart.
190D General Scientific Equip. Co.

Polypropylene Films.....12-page booklet covers markets, properties, processing and converting, and packaging data and includes a table comparing competitive films.
190E Hercules Powder Co.

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190F Western Supply Co.

Tube Cleaner.....for condenser and heat exchanger tubes. They feature pistol-grip, chrome-moly shafting and flushing action. Bulletin Y-48 is offered.
162 *Elliott Company

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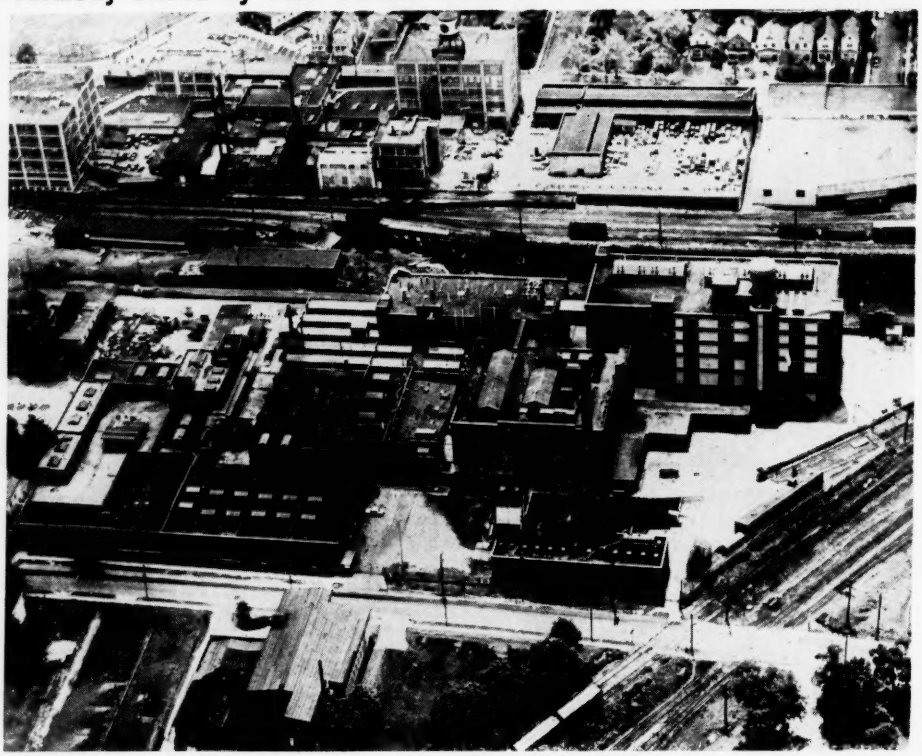

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1—Lead and Brick Lined 1000 gal.
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69—J. H. Day Round Recessed Plate Open Delivery Presses, 18".

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(2) 3' x 5' (14) 5' x 7'
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19—Buffalo Model J Vacuum Chamber Dryers, 60" x 80" with 20 shelves.
8—Atmospheric Truck Dryers with Multi Compartments & Accessories.

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28—Vertical Condensers and Receivers manifolded together.
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1—Raymond # 6669 Super High Side 6-Roll Mill, with whizzer, cyclone, piping and motors.

1—Raymond #5047 High Side 4-Roll Mill, with whizzer, cyclone and piping

1—#1 Raymond Impact Mill, with whizzer, cyclone and piping.

1—Kilby Nickel Single Effect Force Feed Evaporators, 1200 sq. ft.
2—Oliver 5'3"x4' Nickel Clad Rotary Vacuum Filters.
2—Pfaudler 300 and 200 gal. Glass Lined Jkt. Agt. Reactors.
1—Sperry 30" C.I. Filter Press, 27 chambers.
1—Buflovak 32"x90" Dble Drum Dryer.
4—Feinc 8'x12' Rotary Vacuum Steel Filters, string discharge.
2—6'6" dia. x 60' Rotary Dryers.
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5—Glascote 500 gal. glass lined, Jacketed Reactors.
5—Pfaudler 26 sq. ft. glass lined Condensers.
1—Bird Young 18" x 24" rubber covered Rotary Vacuum Filter with Hastelloy "C" valve.
3—Lightnin Model 322-TEQ Drives, with rubber covered turbine agitators.

BRILL FOR VALUES

CENTRIFUGES

3—Bird 18" x 28", 24" x 38" Solid Bowl Continuous 304 S.S.
1—Bird 40" x 60" Solid Bowl Continuous 316 S.S. UNUSED.
5—Sharples C-20 and C-27 Super-D-Hydrator 316 S.S.
3—Sharples PY 14, PN14 Super-D-Canters 316 S.S.
2—Sharples #16, 304 S.S., 3 HP motor.
1—Tolhurst 40" 347 S.S. imperforate basket 15 HP UNUSED.

TANKS

25—500 to 3500 gal. Vertical 304 S.S. Tanks opened and closed, some agitated.
6—7500, 6000 and 2000 gal. Rubber Lined Tanks.
1—1500 gal. Stainless Pressure Tank, 5' x 10', 90#.
1—2000 gal. Horizontal 304 S.S. Tank 5' x 12'.
1—2500 gal. Vertical 304 S.S. Tank 8' x 7'.
1—10,000 gal. Rubber Lined Tank 10' x 17'6".
1—5500 gal. 316 S.S. Clad Pressure Tank 250 PSI.
2—3,000 gal. Aluminum Tanks, 7' x 11'
5—25,000 gal. Aluminum Storage Tanks.

REACTORS—EVAPS—CONDS—COLUMNS

1—Pfaudler 125 gal. 304 S.S. Jkt. Agit. Reactor, 150# int., 125# jacket.
2—Pfaudler 50 gal. glass lined, Jacketed, Agitated Reactors.
1—650 gal. 304 S.S. Reactor with 100 sq. ft. Bayonet Heater.
1—O. G. Kelly 3000 sq. ft. 309 S.S. force feed Evaporator UNUSED.
1—550 sq. ft. Buflovak monel single effect Evaporator.
1—300 sq. ft. Swenson 347 SS Single Effect Evaporator.
1—250 sq. ft. Buflovak 304 S.S. Single Effect Evaporator.
10—Stainless Heat Exchangers; 910, 536, 370, 250, 131, 70 sq. ft.
1—4'6" x 46' 316 S.S. Clad Column, 250 PSI.
8—3' x 20', 30" x 19' 347 SS Packed Columns.
1—24" x 35' 304 S.S. Bubble Cap Column.

FILTERS

1—Niagara 110 sq. ft. Vert. 316 S.S.
1—Niagara 92 sq. ft. Vert. Jkt. 316 S.S.
2—#10 Sweetland, 27 leaves 4" centers
1—#5 Sweetland 304 S.S., 120 sq. ft.
1—Oliver 6' dia. Horizontal 316 S.S.
1—Oliver 4' dia. Monel Horizontal.
1—U.S. 200 sq. ft. 304 S.S. Auto-Jet.
1—Hercules 400 sq. ft. 304 S.S. Pressure.
3—Oliver Precoat 5' x 6', 5' x 10', 8' x 10'.
1—Oliver 5'3" x 8' Steel Rotary Vac housing.
1—Feinc 3' x 1' 316 S.S. Rotary Vac.

DRYERS

1—Buflovak Vacuum Shelf, 17—60" x 80" shelves.
2—Buflovak 42" x 120", atmospheric double drum complete.
1—Buflovak 32" x 90" Atmos. Twin Drum.
2—Devine 4' x 9' single drum, atmospheric.
1—Buflovak 3' x 10' Rotary Vacuum.
6—Louisville Rotary Steam Tube, 6' x 30', 6' x 50'.
2—Louisville 8' x 50' Stainless Steel lined Rotary.
3—Rotary Dryers 6' x 50', 7' x 80", 8' x 80'.
1—Louisville 4½' x 25' Inconel Rotary.
1—Link Belt 6'4" x 24' Roto Louvre 316 S.S.
1—Atmos. Tray, 13 shelves, 3' x 3'.
2—10' and 4' dia. 304 S.S. Spray Dryers.
2—Wyssmont, 304 S.S. 6'2" and 9'6' dia.

MIXERS

1—Sturtevant 75 cu. ft. 304 S.S. Rotary Batch Blender 20 HP.
1—Abbe 110 gal. 304 S.S. Jacketed Agitated Vacuum Dispersall Mixer.
2—Baker Perkins 150 and 100 gal. jacketed double arm Sigma blades.
1—Baker Perkins 50 gal. jacketed.
5—Day "Cincinnatus" double arm, 250 and 100 gal.
2—Steel jacketed Powder Mixers, 225 and 350 cu. ft.
2—40 and 50 cu. ft. Powder Mixers 304 SS
2—Day 120 cu. ft. Jumbo Powder Mixers 25 HP motors.
1—45" dia. Lancaster Mixer 7½ HP motor.

MISCELLANEOUS

3—Kinney Vacuum Pumps, 1000 cfm, 10 microns, 15 HP.
3—Hardinge 6' x 36", 5' x 22" steel lined conical Ball Mills.
1—Sturtevant 6' dia. Air Separator 10 HP.
1—Komarek Greaves Briquetting Press 3½" face rolls.
3—Mikro Pulverizers, 1SH, 1SI and Bantam.
3—Swenson Walker Continuous Crystallizers, 24" x 30' sections.
2—Tyler Hummer 3' x 10' Double Deck Screens.
5—Day Roball Sifters, 40" x 120", 40" x 84", Double Deck.
6—Nash H6, H5, L5 Vacuum Pumps.
3—Nash H6, L3 347 SS Vacuum Pumps.
2—Stokes Rotary Tablet Machines DD2-DDS2.

Partial List of Values—Send for Complete Circular

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10—H.P.M., Hydraulic Steeping Press, 118 Ton Cap., 43 Plates, 55"x20" • Pressing Surface, 168" Max. Travel, Pressure Design 2485 PSI, Self-contained Hydraulic Units, 5 HP, 3/60/440 and Control. • 1—Connecting 48"x200' Belt Conveying System, M/D and Control. • 1—Connecting 60"x80' Belt Conveying System, with Side Hopper Feed, M/D and Control.

PRE-SHREDDERS and SHREDDERS

3—BAKER-PERKINS Continuous Pre-Shredders, Jacketed, 3/60/220/440, 25HP, M/D, Gear Reduction Drive and Control • 3—Connecting 18" x 25' Belt Conveyors, Gear Reduction Drive, Motor and Control • 3—BAKER-PERKINS 32" Continuous Worm-Type Shredder, Jacketed, Knife-type Blades, 75 HP, M/D, 3/60/220/440 and Control • 1—BAKER-PERKINS Size 18 Shredder, Jacketed, 650# Cap., WICKERS Hydraulic Tilt Device, Twin Sigma Blades, Gear Reduction Drive, 20 HP, M/D, 3/60/220/440 and Control.

CHURNS

11—BAKER-PERKINS 900 Gal. Wet Churns, Water Jacket, Gear Reduction Drive, 20 HP, Explosion-proof Motor and Control.

4—BAKER-PERKINS 1650# Dry Churns, Stainless Steel Sprayed, Gear Reduction Drive, 5 HP, Explosion-proof 3/60/220/440 Motor and Control.

VISSOLVERS AND DISSOLVERS

10—BAKERS-PERKINS Size 2E Vissolver, 950 Gal. Cap., 60 PSI Jacket, 600 PSI Internal Pressure, Gear Reduction Drive, 40 HP, Explosion-proof 220/440 Motor and Control.

6—BAKER-PERKINS Size 2E Dissolver, 900 Gal. Cap., Water Jacketed, Gear Reduction Drive, 20 HP, Explosion-proof 3/60/220/440 Motor and Control.

SALT EQUIPMENT

1—BUFLOVAK Single Effect Spin Bath Evaporator, 13'4" x 108", Karbate and Rubber Lined Steel, 18,000# Cap. Per Hr., 20 HP, 3/60/220/440 Motor and Control • 1—SWENSON Vacuum Chrystalizer, 10'6" Diameter, Rubber Lined, Complete with Controls • 1—SWENSON LTV Single Effect Evaporator, 4'3" Diam., Rubber Lined, Complete with Controls • 1—SWENSON Double Effect Evaporator, 8' Settler Tank, Calandria-type, 40 HP, 3/60/440 Motor and Control • 1—SWENSON Vacuum Filter Repulper, 48" x 24", 3 HP, M/D, Complete with Controls • 1—BARTLETT & SNOW Sulphate Dryer, Style M, Stainless Steel, 36" Diam. x 16' lg., 3720# Material Feed Per Hr., 3650# Discharge Per Hr., 3 HP M/D.

FILTER PRESSES

12—SHRIVER Filter Presses, Plastic Coated, Size 30, Closed Delivery, 23 Plates, 24 Frames, Pressure Design 100 PSI • 17—SHRIVER Filter Presses, Size 30, Closed Delivery, 23 Plates, 24 Frames, Pressure Design 100 PSI • 12—SHRIVER Filter Presses, Plastic Coated, Size 12, Filter Pressure 100#, Stainless Steel Plates • 6—SPERRY Filter Presses, Size 12, Pressure 100#.

DIALYZERS and PUMPS

40—BROSITES Dialyzers, Web Cell, 121 Plates, 60" x 22", Screw Activated • 3—LAWRENCE 6" Double Vertical Pumps, Submerged-type, 75HP, 3/60/440 Motor and Control.

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AURORA, KARBATE, LABOUR, WORTHINGTON, NASH, GOULD, DeLAVAL, INGERSOLL-RAND, AMERICAN HARD RUBBER, SLURRY, Pumps, etc., in Asst. Sizes and Types, Stainless Steel, Rubber Lined, Lead Lined, Cast Iron, etc. From 1 HP to 75 HP, Direct Connected M/D.

REFRIGERATION

800 Ton CARRIER Centrifugal Refrigeration Machine, Model 17M63. Gear Reduction, Murry Steam Turbine Drive, Carrene #2 Refrigerant, Cooling 900 Gal. Per Min., Heat Exchanger, Condenser, Gauges and Controls • 285 Ton CARRIER Refrigeration Machine, Size 17M, Gear Reduction Drive, 300 HP, 3/60/440 Motor and Control, Heat Exchanger • 415 Ton CARRIER Centrifugal Refrigeration Machine, Size 17M51, Gear Reduction Drive, 400 HP, 3/60/440 Motor and Control, Heat Exchanger • 360 Ton CARRIER Refrigeration Machine Model 17MB44-7-6, Gear Reduction Drive, 400 HP, 3/60/440 Motor and Control • 2—CARRIER Freon Compressor, #5H60-899, 2 Cyl., 40 HP, 3/60/220/440 Motor and Control • CARRIER Compressor, Model 5H80-A210, 50 HP, 3/60/220/400 Motor and Control.

AIR CONDITIONING

CARRIER Air Washer, Type 29C, 97,500 CFM, 163 Sq. Ft., 600 FPM Air Velocity, Complete with Pumps, 75 HP, 3/60/220/440 Motor and Control, 40 HP Exhaust Fan • CARRIER Air Conditioning Unit, 98,000 CFM, 162 Sq. Ft., 605 FPM Air Velocity, Complete with Pumps, 75 HP, 3/60/220/440 Motor and Control, Supply Fan. 30 HP Exhaust Fan • AIR & REFRIGERATION CORP., Air Conditioning Unit, Class 1-10-12, 390,000 CFM, Capillary-type, Complete with Pump, 75 HP, 3/60/440 Motor and Control.

OTHER MISCELLANEOUS AIR CIRCULATING EQUIPMENT

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CIRCLE F ON READER SERVICE CARD

IMMEDIATE DELIVERY

CENTRIFUGES: Bird, Model LB 325, 18" x 28" stainless steel w/ 15 HP motor. DeLaval Mod 94-21 and Mod. SVK 5R.

DRYERS: F. J. Stokes 3 x 10, Mod. 50-B, stainless vac. type; DeVine, Mod. 4-C, 9-shelf, mild steel, vac. type.

MIXERS: Midget Banbury; J. H. Day 8 and 20 Gal. pony mixers; Baker Perkins, Mod. NIM, 300 gal. double blade type self contained with hyd. pump & tilting device; Hottman w/ 40 HP Motor and S/S twin screws; J. H. Day 200# powder mixer; Howe double ribbon type w/ 15 HP mtr., geared both ends and w/ xtra bull gear & hopper; W & P 100 gal. heavy duty, mild steel; J. H. Day 1,000# double spiral ribbon blender.

PULVERIZERS: Morehouse Hi R Mills; Rietz disintegrator; Fitzmill D-6; Prater Model G-09 & Silver streaks; Gruendler Supermaster No. 1 & Mod. No. 3.

REACTORS: (3) Pfaudler glass lined, jacketed, acitated, ASME coded; 100 gal., 300 gal. and 500 gal.

TANKS: Groen 40 gal. S/S straight side, sanitary welds, open top; 70 gal. round type jacketed for water; 250 & 300 gal. chem.; (2) 450 gal. S/S open top with liquid level gauge on side and radius cornered bottoms; 730 gal. plain steel jacketed for 40 psi; 2300 and 6500 Gal. S/S lined.

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RAYMOND HI SIDE MILL

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CIRCLE H ON READER SERVICE CARD

Screener 2 Deck S.S., also steel

S.S. Jacketed—Blender—Double Ribbon —240 cu. ft.—total

Reactors 500 gal—750 gal steel

Baker Perkins—100 gal—50 HP, S.S. 2 arm jacketed-vacuum hdr. tilt

Aluminum Evaporator Calandria type—never used—1300 sq ft. tube area

Hydraulic Pumps & motors.

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Newark 5, N. J. MI 2-7634

CIRCLE J ON READER SERVICE CARD

SPECIALS

Kettles: 275 gal. type 316 st. steel, agitated.
Mill: Day Hispeed Model B 14x30" 3-Roll.
Column: 24" x 22', 316 stain, steel.
Pebble Mills: Abbe #3, #6, and others.
Dryer: American 24x48" dbl. drum.
Dryer: Bowen lab. spray, st. st.
Evaporator: Buflovak sgl. eff. st. st. 94 sq. ft.
Dryer: Porter 2 x 4' vac. drum., st. st.
Centrifugal: Tolhurst 26" rubber, 2-speed.
Filter: Sweetland #5 st. st. lined.
Filter: Oliver precoat 12x2" type 316 st. st.
Vacuum Pans: 42" and 72" stain. steel.
Dryer: Proctor & Schwartz 6-tray st. st.
Mixer: Day 150 gal. dbl. arm jkt.

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78"x18'x1/4" Vulcan 318 SS Bubblecap, 14 trays, 180 caps/tray, 50 PSI.
72"x30'x1/8" Budd 347 SS Bubblecap, 21 trays, 38 caps/tray.
48"x41'x5/16" Vulcan 316SS Bubblecap, 40 trays 70 caps/tray 100 PSI.
36"x21'x1/4" 316 ELC SS Packed, 15 PSI.
36"x20'x3/16" Vulcan 316 SS Packed 100 PSI.
30"x23'x1/4" 316 SS Packed 75 PSI.
14"x17'6"x1/8" 316 SS Packed.
12"x18'8"x3/16" 347 SS Packed 100 PSI.

• COLUMNS •

20"x27' GLASS LINED 50 PSI full vacuum
16"x21' GLASS LINED Scrubber
16"x10' GLASS LINED 25 PSI full vacuum

• REACTORS •

Pfaudler 500 gal ELL Gl. Lined Jktd. Agit.
Pfaudler 300 gal. EL Gl. Lined Jktd. Agit.
Dopp 1700 gal Ni-Resist Jktd. Agit.
Dopp 1000 gal Ni-Resist Jktd. Agit.
Vulcan 1000 gal Everdur Coiled, Agit.
Patterson 1000 gal Steel Jacketed
Patterson 500 gal Steel Jktd. Agit. 2HP XP
Alloy Tank 750 gal Stainless Pressure Still
Alloy Tank 300 gal Stainless Pressure Still
30 gal. Agit. S.S. 316; 1,000 PSI INT. 319 PSI JKT.

• CENTRIFUGES—FILTERS •

Sharples C-27 Super-D-Hydrator Stainless
40" Fletcher Susp Centrifuge Perf. 15/7½ HP
30" Susp Centrifuge—Imperforate Stainless
Sharples #6 Super Centrifuge Stainless Bowl
5'3"x3' Oliver Precoat Rot Vac Filter SS
4'x1' Bird Young Rot. Vac Filter Stainless
36"x24" Goslin Rot. Vac Filter Stainless
48"x36" Stainless Nutsche Filter
18"x28" Bird Continuous Stainless

• DRYERS—KILNS •

8'x60'x5/8" Al. Chalmers Welded Kiln
7'x45'x1/2" Link Belt Welded Kiln
604-24 Roto-Louvre Dryer Stainless Steel
6'x124'x3/4" Vulcan Kiln
502-16 Roto-Louvre Dryer
4'x40'x3/8" Welded Dryer NEW Shell
6"x8" Buflovak Vacuum Double Drum Dryer
6'x5'6" Blawknox Vacuum Single Drum Dryer
F. J. Stokes 38A Steam Heated Tray Dryer

• COMPRESSORS—VACUUM PUMPS •

Clark 9920 CFM 149PSIA Suct 239PSIA Dis
Al. Ch. Centrifugal 7500CFM @ 42.5PSI, 1250HP
Worthington YO 1360 CFM @ 35 PSI; 150 HP
Worthington 1015 CFM @ 35 PSI Steam Driven
Norwalk Hydrogen Compressor 5 CFM15000PSI
Nash #4 Vacuum Pump 650 CFM @ 15"
Nash TS10 2 stage Vacuum Pumps
Nash L3 Stainless Comp. 127 CFM @ 20 PSI
Stokes 612F 500 CFM @ 1mm Vacuum Pump
Worth. 600 CFM @ 50 PSI Comp. 75HP XP
Ing. Rand 450 CFM @ 100 PSI Comp. 75 HP
Nash CD 663 Stainless Comp. 50 CFM @ 75 PSI

• STAINLESS STEEL TANKS •

108,000 gal. 18'x61'x1/4" flat/cone
17,500 gal. 15'x16'x3/16" flat/cone
11,500 gal. 12'x15'x3/16" flat/cone, agit.
10,500 gal. 10'x23'x3/16" dish cone
4500 gal. 6'x25'x1/4" dish/cone 25 PSI Coil
4000 gal. 8'x12'x3/16" dished Coiled
3500 gal. 8'x9'x5/16" dished heads
1200 gal. 5'x8x1/4" Agitated
750 gal. 4'6"x6'x1/4" dished 42 PSI
500 gal. 4'x5'x5/16" dished heads
(20) Tanks 50 to 400 gal. some agitated

• TANKS •

12000 gal Aluminum 10'x23'3" dished heads
10000 gal Aluminum 9'x23'3" dished heads
7000 gal Aluminum 10'x14' dished heads
20000 gal Steel 12'x24'4"x7/8" dished 100 PSI
10000 gal Steel 8'x30'x3/8" dished 60 PSI
6500 gal Steel 7'6"x20'x1/4" dished
2500 gal Heresite lined 5'x15'6" 68 PSI
2250 gal Steel 6'x19'x5/16" dished 114 PSI
1250 gal Steel 5'x8' dished Agit. Coil

(8) 96,000 Bbl. Storage Tanks
120'x48' Welded Cone Root

• HAMMERMILLS—CRUSHERS •

Penna SX13 150TPH, 400HP Synchronous Drive
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Raymond #50 Imp Mill Model C2-855
Bacon Hevi-Duty Style B 20"x6" Jaw Crushers
Universal 5"x6" Jaw Crusher Manganese Jaws
Sturtevant 8"x5" Double Roll Crusher
Raymond #51 Imp Mill

• SPECIAL ITEMS •

MIXER 300 gal. B.P. STAINLESS Sigma 18DIM
ENTRAINMENT SEPARATOR—Monel 36"x8'
CALENDER—12" 3 Roll Perkins
GRANULATOR—Stokes Oscillating #243E 5 HP
TABLET PRESS—Stokes Rotary RDS3-DDS2
FORK LIFT TRUCK—1 & 3 Ton Gas Engine
TRIPLEX PUMP—2¼x4 Stainless 2000PSI
BLOWER 2500 CFM 10 PSI Read Standardair
CRYSTALLIZER Squire 40"x30" Agit. Jktd.
CRYSTALLIZER Buflovak 6' Vacuum Jktd. Agit
CRYSTALLIZER Swenson 24"x20' Jktd. SS304
AIR DEHYDRATOR-Anders 8FA Automatic
ABSORPTIVE DRYER-Kemp FE02-S Dual Tower
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SIFTER 40"x84" Roball Single Deck
SIFTER 60"x84" Rotex STAINLESS 1 Deck
SIFTER 48" Sweco-Triple Deck Model A9062
CONVERTER—St. Wells 10'x29' 10000 sq. ft.
BRIQUETTE PRESS Komarek Greaves 27"x24"
EVAPORATOR—435 Sq. ft. Single Effect S.S.
BALL MILL Traylor 8'x11' Steel Lined 300 HP
CENTRIFUGAL PUMPS—STAINLESS—1" to 3" 10 to 750GPM 35 to 100' Head
LARGE QUANTITY STAINLESS STEEL PIPE & VALVES

• CONDENSERS—HEAT EXCHANGERS •

Pfaudler 2", 3" & 4" Double Pipe Coolers, Gl. Lined
6931 Sq.ft. Steel 2"x11ga.x12' Tubes
1056 Sq.ft. Steel ¾"x16ga.x10' Tubes
141 Sq.ft. Steel ¾"x14ga.x8' Tubes

• STAINLESS HEAT EXCHANGERS •

2320 Sq.ft. 33"x21'—1"x16ga.x16' Tubes
1000 Sq.ft. 27"x168" ¾"x16ga.x14' Tubes
890 Sq.ft. 22"x20'8" 5/8"x16ga.x14' Tubes
800 Sq.ft. 23"x17'10"—3¼"x16ga.x16' Tubes
615 Sq.ft. 22"x15'9"—5/8"x16ga.x10' Tubes
420 Sq.ft. 18"x9'6"—¾"x18ga.x8' Tubes
300 Sq.ft. 14"x19'6"—¾"x18ga.x12' Tubes
235 Sq.ft. 16"x8'3"—5/8"x16ga.x7' Tubes
188 Sq.ft. 11"x16'8"—5/8"x14ga.x12' Tubes
146 Sq.ft. 11"x13'10"—5/8"x16ga.x9'6" Tubes
68 Sq.ft. 8"x17'3"—¾"x16ga.x16' Tubes
1860 Sq.ft. REBOILER 54"x23', 1"x12' Tubes

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STAINLESS STEEL TANKS

13,300 gal., 11'10"x15'7", cone top.
12,000 gal., 11'6" x 15'6", cone top.
11,500 gal. Pfaudler horiz. blue glass-lined, 8' x 30', dished, coils.
3650 gal., 10' x 7', open top.
3000 gal., 5' x 19', T347SS, ASME 60 psi, dished heads.
1350 gal., 4'x14', T347SS, ASME 60 psi, dished heads, int. coils.
1300 gal., 7' x 4'6", T321SS, closed
1100 gal., 4' x 11', T347SS, ASME 60 psi, 3/16" shell, ¼" heads.
476 gal., 4'6" x 4', open top.
475 gal., 5'6"x2'6", open top.
445 gal., 6'x2', open top.
300 gal., 4'x3', T347SS, ASME 60 psi, dished heads.
285 gal., 41"x49", open top.
260 gal., 40"x48", closed top.

SEND FOR DETAILED CIRCULAR

STEEL PRESSURE TANKS

28,000 gal. 11' x 38', dished, ASME 75 psi.
28,000 gal. 11' x 38', lead-lined.
14,000 gal., 8' x 36', dished.
11,000 gal., 8' x 27', dished, ASME 300 psi.
9000 gal., 8' x 23', dished.
5200 gal., 6' x 24', dished, 60 psi.
3300 gal., 6' x 15-6", dished, ASME 125 psi.

BOILERS

3—3000 CFM Edgemoor waste-heat boilers, 250 psi, 535 sq.ft., ASME.
5—435 HP Comb. Eng. water-tube boilers, 300 psi, 4620 sq. ft., 34,500 lb. steam/hr. @ 225% of rating, gas or oil fired.

COMPRESSORS—BLOWERS

Worth 3500 CFM air comp., 24 x 15, #LTC-4, 500 HP gas driven.
Chicago-Pneu. 3026 CFM air comp., size #19-32-30-18 x 24, horiz. steam driven.
Elliott turbo-blowers, 11,620 CFM, type 0, 15.9 psi discharge, 125 HP.
Ing.-Rand 6 x 6 x 5 air comp., V-type, 2 cyl, #67D9, type 30.

KETTLES—REACTORS

1400 gal. Pfaudler blue glass-lined jacketed kettles, 84" dia. x 54" high, open top, Stainless Steel cover, 3 HP Agit., Adj. baffle.

1250 gal. Pfaudler blue glass-lined jkt. reactors (Sulphonators), 72" dia. x 72" high, closed, 3 HP Agit.

600 gal. Plaudler Stainless Steel ammoniating & crystallizing jkt. kettles, 60" dia. x 46" high, open.

250 gal. Plaudler blue glass-lined jacketed kettles, 42" dia. x 36" high, open top, Stainless Steel cover.

STAINLESS PUMPS

Worthington Worthite Cent. Pumps; 4" x 3", 3" x 2", 2" x 1½", 1½" x 1", w/motors.
LaBour 2" 316 SS self-priming cent. pumps w/motors.
Aurora 1½" SS sump pumps

COLUMNS—HEAT EXCHANGERS

24" dia. x 15' high Duriron packed columns, 1" cast sections.
24" dia. x 33' high Duriron & St. St. packed column.
1450 sq. ft. T347SS gas condensers, 3-pass Vert. units.
1000 sq. ft. Duriron pipe coolers.
564 sq. ft. Stainless Steel burner-Preheaters, gas condensers, 3-pass.
400 sq. ft. Stainless Steel open-pipe coolers, 2" IPS pipe
Amer. spiral heat exchangers T316L S/S: 162, 72 sq. ft.
75 sq. ft. nickel 2" pipe coil
Duriron pipe coolers, 159, 130, 125, 99, 54, 44, 42, 10 sq. ft.
Cottrell lead-lined precipitators

STAINLESS PIPE—VALVES

VAPOR PIPE—6" to 20" dia.
PIPE—Sch. 10 & 40, 1"—6".
VALVES—Gate, globe, etc.

PERRY EQUIPMENT CORP.

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PHILADELPHIA 22, PA.
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CIRCLE N ON READER SERVICE CARD

NEW FILTER, stainless steel NIAGARA 48" dia. w/510 sq. ft.

NEW GRANULATOR #24, Stokes oscillating, S/S, also used 43A, S/S

NEW VOTATOR, S/S, lab. model, 4 speed
FURNACE, electric, 5"X12"X30" muffle, 1600°C, Globar, w/50KVA transformer

MIKRO PULVERIZERS, 2 model 2TH w/ 10HP motors & vari-drive feeds

OVEN, Truck/Tray, 650° F. electric, 5'X6'6"X14', self-contained package unit.

LAWLER COMPANY

Durham Ave. Liberty 9-0245 Metuchen, N. J.

CIRCLE O ON READER SERVICE CARD

LOCOMOTIVES—RR CARS & CRANES
9 Gen. Elec. 20, 25, 45, 65, 70, 80, 100, 125 Ton
25-Ton Industrial Brownhoist 60' Boom Crane
200—50 Ton Box 300—70 Ton Gondola Cars
300—1½, 5, 20 & 30 yd Dump Cars
40-Ton Amer 60' Boom Diesel Loco Crane

PLANT EQUIPMENT
2—Wemco 2M-HMS Plants
No. 1 Sturtevant Hammer Bar Mill
No. 2 Robins Vertical Cone Crusher
24" x 24" Jeffrey Single Roll Crusher
No. 1 Sturtevant Rotary Fine Reduction Crusher
F55 Syntron Grizzley Feeder
5' x 8' & 4½' x 9' KVS Air Swept Ball Type Mills
Ball Mills: No. 56, 5' x 5', 6' x 4', & 7' x 22'
Hardinge Mills: 3' x 8', 5' x 22" & 8' x 22"
5' x 22" Hardinge Air Sweep Ball Mill complete New 1951
Rod Mills: 4' x 11', 6' x 12' & 7' x 15'
Jaw Crushers: 9" x 24", 10" x 30", 13" x 24", 14" x 28", 18" x 36", 30" x 36", 66" x 84"
Crushers, Fine Reduction: 22", 2', 3', 4', 5½' & 7'
636 & 436 Allis Chalmers Hydrocone Crushers
Crushers Roll: 24" x 14", 30" x 14", 40" x 16"
Rotary Dryers: 5' x 30', 6' x 50', 6' x 70' & 8' x 80'
Rotary Kilns: 6' x 70', 7' x 110' & 9' x 160'
2—45" x 120" Buflovak Atmos Double Drum Dryer
Roto Louvre #207-10 Type 316 S.S. Link Belt
150—1½, 2 & 4 yd & 30 yd Dump Cars
5 & 10 HP LB Car Pullers
16' Gayco Centrifugal Air Separators
BX-105 Sutton Steele & Steele Air Table NEW
6—30" x 32" Dings Magnetic Head Pulleys
690', 2200', 3068' & 3600-7500' IR. Compressors
4100 CFM Sly Dust Collector
WANT BUY DRYERS—KILNS—CRUSHERS

R. C. Stanhope, Inc., 60 E. 42 St., N.Y. 17, N.Y.
Tel. MU 2-3075 or MU 2-1898

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TURBO-GENERATORS • DIESELS
PUMPS • FANS • BURNERS • HEATERS

Large Selection . . . New and Used

EXPERIENCED ENGINEERS TO ASSIST YOU

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WABASH

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PHONE IN 3-0303
3300 W. PATTERSON AVE.
CHICAGO 45, ILL.

CIRCLE Q ON READER SERVICE CARD

PROFIT SAVERS

Our Price Makes It Possible!

Oliver Precoat Filter, 3' x 6' rubber covered, oscillating agitator, vari-drive. Excellent condition. Immediate delivery from stock.

The Price Will Amaze You —

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123 Townsend St. · San Francisco 7, Calif.

CIRCLE R ON READER SERVICE CARD

PERRY FOR PROCESS EQUIPMENT

CHOICE ITEMS AT ORANGE, TEXAS

3—Worthington 160 ton steam-jet vac. refrig. units.
1—1200 gal. horiz. steel reboiler, 5′ x 8′, dished, 320 sq. ft. coils.
2—1800 cu. ft. Read T304 SS weigh hoppers, on scales.
4—T316 SS blowers; Buffalo, Amer.
1—Sharples #16P super centrif., T304 SS, press-tite.
2—Sharples C-20, Super-D-Hydrators, T316 SS, w/timers.
2—2600 gal. T316 SS tank, 7′ x 8′, dished, coils.
1—2250 gal. T316 SS tank, 7′ x 6′-3,″ dished, Agit.
2—1450 sq. ft. T316 SS Condensers.
2—Vulcan 10 plate T316 SS bubble-cap columns or scrubbers: 110″, 60″ dia.
6—685 gal. T316 SS vert. tanks, 3′ x 13′, coils.
15—100 gal. T316 SS separator tanks, 20 PSI WP, dished.
3—800 sq. ft. T316 SS condensers.

DRYERS—KILNS

2—Buflovak 42″ x 120″ double drum dryers, ASME 160# WP.
1—American 42″ x 120″ dbl. drum.
1—Buflovak 42″ x 90″ dbl. drum.
2—American 36″ x 84″ Dbl. Drum.
1—Buflovak 32″ x 52″ Dbl. Drum.
1—American 36″ x 84″ double drum dryer, ASME, VACUUM.
1—Buflovak 5′ x 12′, single drum dryer, Vacuum UNUSED.
5—F. J. Stokes #138J-16, 195 sq. ft. vac. shelf dryers.
1—Vulcan 10′ x 11′ x 175′ rotary kiln.
2—B. & Snow 8′-6″ x 70′ rotary dryers, ⅝″ welded shell, late model, complete.
2—Davenport 8′ x 60′ rotary, 7/16″ welded burners, fans, etc.
1—7′6″ x 62′ rotary kiln, ½″.
1—6′ x 150′ rotary kiln, ⅜″ welded, w/burners, etc.
2—Louisville 4′6″ x 25′ rotary steam-tube dryers, welded.
1—Bartlett & Snow 3′ x 15′ rotary dryer, Everdur metal shell.

PRESSES

3—Komarek-Greaves 160,000 psi briquette presses.
4—Davenport dewatering presses; #1A, 2A, 3A.
1—Stokes #T single-punch tab. pres.
1—Stokes #RD-3 rotary tablet press.
1—HPM 63 ton steeping press, UNUSED.

EVAP.—STILLS
COLUMNS—CONDENSERS

1—630 sq. ft. Struthers-Wells T316 SS Calandria evap.
7—4050 sq. ft. calandra type evap., copper tubes, cast iron shell.
1—1250 sq. ft. Mojonnier dbl.-effect Stainless Sanitary evaporator.
4—Buflovak double-effect stainless evap. vert. long-tube type: 1025, 840, 710, 588 sq. ft.
1—250 sq. ft. Buflovak T304 SS, single effect recompression evap.
1—118 sq. ft. Stokes T316SS Still.
1—Vulcan 110″ dia. x 16′ high T316SS bubble-cap column, 10 trays.
1—Vulcan 60″ dia. x 16′ high, T316SS bubble-cap column, 10 trays.
6—30″ x 19′ T347 SS packed columns.
1—1960 sq. ft. T316SS exchanger remov. bundle, ASME 75# WP.
1—1450 sq. ft. T316SS condenser.
5—1400 sq. ft. T316 SS gas converters.
1—900 sq. ft. T304 SS exchanger.
3—800 sq. ft. T316SS condensers.
1—730 sq. ft. T316 SS exchanger.
1—510 sq. ft. T316SS condenser.
30—T316 SS heat exchangers & condensers: 425, 410, 400, 290, 277, 200, 186, 165, 150, 142, 105, 83, 73, 54, 50, 30 sq. ft.

MIXERS—MILLS

40—Baker-Perkins #17, 200 gal. sigma-blade, jkt. mixers.
1—Baker-Perkins #15, 100 gal. Disp., T347SS 25 HP drive.
1—Baker-Perkins #15-UUMM, 100 gal., Disp. blade, ASME jkt., 100 HP, Comp. Cover, motorized tilt.
1—J. H. Day #6, 100 gal., St. St. sigma.
2—J. H. Day #5, 75 gal., sigma.
2—145 cu. ft. ribbon mixers.
1—Raymond 50″, 5-roller hi-side, mill.
1—Raymond 66″, 6-roll hi-side mill.
13—Abbe 6′ x 8′ patch pebble mills.
2—Hardinge 7′ x 36″ conical mills.
1—Sturtevant 75 cu. ft. T304SS blender
1—Allis 6′ x 12′ rod mill
1—Gemco 60 cu. ft. T304SS conical blender.
1—Bonnot 5′ x 10′ ball mill.

STAINLESS STEEL TANKS
(T304 UNLESS NOTED)

3—20,000 gal., 14′ x 15′, T316LC, cone bottom, ⅜″.
2—13,000 gal. 11′-10″ x 15′-7″.
2—12,000 gal., 11′-16″ x 15′-6″.
1—11,000 gal., 9′-6″ x 20′, dished, UNUSED.
5—3650 gal., 10′ x 7′, vert., open.
1—3350 gal., 8′x8′-6″, agit., 50 psi.
1—3300 gal., 6′ x 14′-6″, vert.
1—3250 gal., 6′ x 15′, T316.
3—3000 gal., 5′ x 19′, T347, ASME 60 psi.
2—2600 gal., 7′ x 8′, T316, dished.
1—2250 gal., 8′ x 6′, T316.
5—2100 gal., 8′ x 5′6″, dished.
1—2100 gal., 6′ x 9′, T316, cone.
12—1750 gal., hoppers, 4′-5″ x 7′-4″ x 9′-2″.
4—1350 gal., 4′ x 14′, T347, dished, ASME 60 psi coils.
5—1350 gal., 7′ x 4′-6″, T321.
1—1300 gal., 6′ x 6′, ⅜″, dished.
3—1100 gal., 4′ x 11′, T347, ASME 60 psi.
3—1000 gal., 4′-6″ x 8′-6″, dished.
3—850 gal., 4′ x 9′, ⅜″, dished.
1—800 gal., 5′x5′-6″, ¼″, dished.
3—750 gal., 5′ x 5′, 3/16″, dished.
6—685 gal., 3′ x 13′, T316, coils.
3—300 gal., 4′ x 3′, T347, ASME 60 psi.

PARTIAL LIST
SEND FOR COMPLETE LIST!

KETTLES—REACTORS

1—2000 gal. Glascote blue G/L reactor, ASME 50 psi or vac. int., 90 psi jkt.
3—1350 gal. T347SS Kettles, open top.
1—1000 gal., T316 SS jacketed reactor, ASME, UNUSED.
1—1000 gal. Dopp cast iron Kettle, 125# jacket, 15# int., Agit.
1—750 gal. Graver T304SS jkt. fermenter, ASME 30# int., 30# jkt., 10 HP Turbine Agit.
2—600 gal. T304SS reactors, Jkt., Agit.
2—500 gal. T304SS reactors, jacketed, ASME, Vacuum—Unused.
6—465 gal. T304LSS reactors, jacketed, 150# int., 175# Jkt.
1—300 gal. T304 SS jacketed reactor, Vac. ASME—UNUSED.
1—300 gal. Pfaudler blue G/L reactor, Agit., Jkt., ASME.
1—200 gal. T304SS jkt. reactor.

PERRY EQUIPMENT CORPORATION
1413-21 N. SIXTH ST. PHILADELPHIA 22, PA.
Phone POplar 3-3505

CHEMICAL & PROCESS MACHINERY PERRY EQUIPMENT INDUSTRIES

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STRETCH YOUR $$$$ at M&E

6—Beach Russ Model 100 Vac Pumps, type RD, with 5 HP. 100 CFM at 10 microns

1—10' x 203' Rotary Kiln, riveted constr. Comp. equipped. Excellent cond.

1—Elliot Model O positive Blower, 6000 CFM @4.5 PSI. 230 HP Elliot Motor

1—Oliver 3 x 6' all rubber rotary cont Vac Precoat Filter. Vari-speed mtr. Rocker agitator

2—Buflovak 42" x 90" dbl drum Dryer. Comp. Code constr.

2—Raymond #1 auto Pulverizers. Each w/5' single Whizz Separ

1—New Kelly SS Evaporator. 3000 sq ft 750-1" OD 12 ga tubes 15' long

1—New Kemp Model DB-6 Dehydrator. Ser #D-1040. "Dri-Breadher". Complete

MACHINERY AND EQUIPMENT CO., INC.
123 TOWNSEND ST. - SAN FRANCISCO 7, CALIFORNIA

CIRCLE T ON READER SERVICE CARD

OCTOBER SPECIALS

Pfaudler 1500 gal. glass lined Tank, closed top
Stokes vac. shelf dryer 2 shelf 40" x 42"
Gruendler #3 Hammermill, Whir.beater, 22"
Day #40 Imperial jkt. 300 gal. Mixer 40 HP
Simpson 24" Lab. SS Mix Muller, 1½ HP motor
Buflovak 4' x 8" Lab. SS double drum Dryer
2 Fitz Mills Model D, 5 HP motors
Abbe 5'x6' jktd. Ball Mill, chrome mang. steel
Ribbon Blenders, Steel & SS, all sizes, new & Used

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1800 HP WESTINGHOUSE GAS TURBINE
driving two
CLARK CENTRIFUGAL COMPRESSORS
2 compressors in tandem, Model 2M5,
7000 CFM AIR, 100 PSIA—Will Separate
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Phone SAginaw 1-3442 Chicago 17, Ill.

CIRCLE CC ON READER SERVICE CARD

Baker Perk. 15 HP. Masticator Mixer.
Pfaudler 10 gal. Gl. Lined closed Jack.
Hersey 5'x26' Rotary Dryer, 316 S.S.
Day Hy—R Speed Mill 20 HP Expl. Pr.
Buffalo 32"x90" Double Drum Dryer.
Centrifugals: 12", 30", 40" & 48".
Centrifuges: Sharples #5 & #6 Stainless.
DRYERS:
Buffalo Vac. Drum Dryer, 24"x20".
Gehnrich Elec. Htd. Dryer 7'x3'x6'.
Despatch Ovens Elec. Heated & others.
3—Devine & Stokes Vac. Shelf Dryers.
Filters: #2 Sweetland 12 Stainless Leaves.
Niagara S.S. Leaf Filter 45.5 sq. ft.
Oliver Rot. Vac. 3'x1'.
Hercules Leaf Filter 36" diam.
Filter Presses: 6" to 36" Iron & Wood.
Kettles, Tanks: S.S. Jack 20 to 1000 gal.
Dopp 350 gal. cast iron Jack. Vacuum.
Devine Impreg. Units 30" to 36" dia.
Mills: Raymond #00, 3 HP, & #0000.
Mikro Pulverizers #4, 2, 1, & Bantam.
Hammer Mills & Pulverizers 3 to 50 HP.
Rotary Cutters 1½ to 5 HP & up.
Spr. Waldron Stainless spike crusher.
Pebble, Jar & Ball Mills, Lab. to 6' x 8'.
3 Roll, 9" x 32", 12" x 30", 16" x 40".
Lehman 4 Roll W.C. 12' x 36" Steel.
Colloid Mills 1½ H.P. & up.
MIXERS: BP & Day 5, 15, 75, 100 & 150 gal.
Change Can Mixers 8, 15, 40, 150 gal.
Sprout-Wald., 10,000# horiz. Spiral Mixer.
Day Jumbo 700 gal. horiz. mixer.
Spiral Mixers, 3000, 1000, 600, 200 etc.
Lancaster 6' dia. 25 HP.
Pumps: Stokes etc. Vac. 10 to 500 CFM.
Gould 75 HP, Centrifugal 250 PSI.
Sifters: Day, Robinson, Rotex type.
Tablet Machines: Stokes R. Colton 4½ T, single punch, Stokes RDI Rotary etc.
Hydr. Presses, Plastic & Rubber Machy.
Partial Listings. Write For Bulletins

STEIN EQUIPT. CO.
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- Wrappers
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- Mixers
- Pulverizers
- Grinders
- Dryers
- Sifters
- Cappers
- Tablet machines

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UNION STANDARD EQUIPMENT CO.
318-322 Lafayette St., New York 12, N. Y.
Phone: Canal 6-5333-4-5-6

CIRCLE X ON READER SERVICE CARD

OUTSTANDING VALUES!

Ribbon blenders, SS, 190 and 54 cu ft. Simpson style UD, #2 mixer mullers, 6' pans. Devine #5-A, 11 shelf dryer, 40" x 43". Williams (Zenith) 3 roll mill.

CHEMICAL & PROCESS MACHINERY CORP.
50-52 9th St., Brooklyn 15, N. Y. HY-9-7200

CIRCLE DD ON READER SERVICE CARD

BEST VALUES

Vacuum Dryer: Stokes 2' x 6' Rotary, jacketed, St.St. T316. With drive, condenser, receiver.
Evaporators: three St.St. Buflovak dbl. eff. units 608-708-845 sq. ft. each.
Evaporator: Mojonnier dbl. eff. St.St. 1250 sq. ft.
Dryers: Double Drum, 42 x 90; 32 x 90 Buflovak.
Dryers: Double Drum, 42 x 120; 36 x 84 American.
Heat Exchangers: (2)-1900 sq. ft. admiralty tubes, steel bodies, ASME.
Twin Shell Blenders: P.K 5 cu. ft. St.St.; P.K. 30 cu. ft. steel, with intensifier
Centrifuges: Tolhurst 40" and 26" Suspended, perf.
Centrifuges: Tolhurst 48" St. T316, Understung, perf.
Filter, Rotary Vacuum with pressure housing, Dorr Oliver 5'3" dia. x 4' face (2).
Tanks: (2) 2300-1500 gal., vertical St.St.
Tanks: (2) 3000-1500-900 gal., vertical St.St. for vacuum with coils.
Kettles: (2) 600 gal. agitated St.St.; with 15 P.S.I. steel jacket.

BEST EQUIPMENT COMPANY
1737 W. HOWARD ST. CHICAGO 26, ILL.
Ambassador 2-1452.

CIRCLE Y ON READER SERVICE CARD

2—New 5000 Gallon Pressure Vessels

Mfgd. by Babcock & Wilcox. ASME rated, 1750# oper. press.; 3572# press. tested, 650 deg. F max. temp.; Weight 80,500# Bit. 1952. Size 23' L x 53" I.D. With piping, valves, fittings, etc.

Pressure pumps—all sizes and kinds available.

EVEREADY—Box 1780—Bridgeport, Conn.
Ed McCallum ED. 4-9471

CIRCLE EE ON READER SERVICE CARD

K M

2—1000 Gal. Type 316 s/s Reactors ASME code complete with agitators and jackets.
2—S/S Centrifuges Bird 12" Susp., AT&M 20" type BB.
2—Vacuum Shelf Dryers 12"x13", 20"x70".
8—60 Gal. 80 Gal. S/S Kettles.

Keith Machinery Corp.
73-15th Street, Brooklyn 15, N. Y.
ST 8-5502 ST 8-3513

CIRCLE V ON READER SERVICE CARD

RAYMOND FLASH DRYING SYSTEM
Complete—Unused
LINK BELT ROTO LOUVRE DRYERS, 6'x24'
316 S/S
SPRAY DRYERS S/S. PRODUCTION & LAB.
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N. J. SNOW EQUIPMENT CO.

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CIRCLE Z ON READER SERVICE CARD

COMPRESSORS

No better values at any price

72 CFM 1500 PSI 6¼-3¾-1⅝x7 CP
80 CFM 3500 PSI 6¼-4-1 7/16x9 IR ES3
138 CFM 100 PSI 7x7, Ing. ES. CP & Joy
208 CFM 350 PSI 9-4x9 Ing. ES2
288 CFM 100 PSI 9x9 Ing. Worth. CP
311 CFM 1500 PSI 10½x7⅛-3⅛-13 IR-ES3
465 CFM 100 PSI 12x11-IR-ES CP.T. Worth HB
502 CFM 125 PSI 12x13 Worth HB
676 CFM 100 PSI 15-9⅛x12 Ing. XRE
686 CFM 100 PSI 14x13 Ing. ES
880 CFM 125 PSI 18-11x10 Ch. Pn. vee 150 HP Syn 3-60-440/2300
1352 CFM 125 PSI 18½-11½x8.. Ing. XLE 200 HP Syn 3-60-4160
2200 CFM 100 PSI 26-15x28 Ch. Pn. vee 350-HP 3-6-4160-3600 .8 PF
1750 CFM 125 PSI 15½-10x10 Ch. Pn. vee 300 HP Syn. 3-60-2300

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE W ON READER SERVICE CARD

FOR SALE

4—Type 302 Stainless Steel vessels 24" O.D. x 28' long overall, conical ends, 0.2" wall, 100# working pressure.

4—Shells, only, suitable for rectifying columns, etc., 23⅝" I.D., 24' long, 0.2" wall, type 302 stainless.

ARTISAN INDUSTRIES INC.
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TWinbrook 3-6800

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GELB

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1—Sparkler Hastelloy "B" Model 18D12 jacketed filter.
1—Sparkler stainless steel Model 33D7 jacketed filter.
1—Dover Type 316 4000 gal. jacketed reactor.
1—Alloy Fabricators Type 316 stainless steel 4000 gal. reactor.

AUTOCLAVES, KETTLES, REACTORS

1—Pfaudler Series R 1500 gal. glass lined jacketed reactor, complete with impeller type agitator, baffle and drive.
1—Glascote Series HR 1000 gal. glass lined jacketed reactor, complete with impeller type agitator, baffle and drive.
1—Pfaudler 750 gal. glass lined jacketed reactor.
2—Pfaudler Series EM 300 gal. glass lined jacketed reactors.
4—Pfaudler Series P glass lined jacketed reactors, complete with agitators and drives, 5, 20 and 30 gal.
1—Glascote 750 gal. glass lined jacketed vacuum receiver.
1—2000 gal. stainless steel jacketed reactor.
1—Blaw Knox 300 gal. stainless steel vacuum reactor.
1—Van Alst 300 gal. stainless steel jacketed kettle.
1—125 gal. stainless steel jacketed autoclave with impeller type agitator and drive, 125 psi jacket, 75 psi internal.
2—Stainless steel 2000 gal. horizontal storage tanks.
6—Blaw Knox stainless steel vacuum receivers, 200 and 100 gal.
1—Alloy Fabricators steel jacketed autoclave, 600 gal.
1—300 gal. Hastelloy "B" jacketed pressure reactor.
2—Theo. Walters Hastelloy "B" 300 gal. jacketed reactors.

CENTRIFUGES

4—Sharples Type 316 stainless steel nozljectors with 40 HP explosion proof motors.
1—Bird stainless steel 40" suspended type centrifuge complete with perforate basket, plow and motor.
3—Western States Type 316 stainless steel 40" suspended type centrifuges complete with perforate baskets, plows and motors.
1—Tolhurst stainless steel 48" Batch-O-Matic centrifuge, NEW.
1—Fletcher 48" stainless and underdriven centrifuge, complete.
1—AT&M 26" Type 316 stainless steel suspended type centrifuge.
5—Tolhurst 40" and 30" rubber covered centrifuges.
1—Sharples Type 316 stainless steel Super-D-Canter, PN-14.
1—Sharples Type 316 stainless steel centrifuge, Model D-2.
1—Sharples Super-D-Hydrator, monel, Model C-27.

DRYERS

2—Louisville 6' x 50' stainless steel rotary dryers.
1—Buflovak 24" x 36 chrome plated double drum dryer.
1—Allis Chalmers stainless steel rotary dryer, 6' x 50'.
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'.
1—Buflovak stainless steel jacketed rotary vacuum dryer, 5' x 30'.
1—Link Belt steel roto louvre dryer, Model 207-10.
1—Link Belt steel roto louvre dryer, Model 502-20.
1—American 42" x 120" double drum dryer, ASME, complete.
1—Buflovak steel jacketed rotary dryer, 3' x 15'.
2—Stainless steel pilot plant spray dryers.

FILTERS

2—Oliver stainless steel rotary filters, 3' x 2' and 3' x 4'.
12—Sweetland #12 pressure leaf filters with 72 stainless leaves.
1—Niagara stainless steel filter, Model 510-28.
1—Sperry 36" x 36" heresite covered filter press, 40 chambers.
10—Shriver plate and frame filter presses, 12" to 42".

THE GELB GIRL—OCTOBER 1961

MIXERS

1—Abbe 10 gal. steel double arm sigma blade jacketed mixer.
1—J. H. Day 200 gal. stainless steel double arm sigma blade jacketed mixer.
3—Sprout Waldron 30 cu. ft. jacketed double ribbon blenders, steel.
1—Gemco stainless steel double cone jacketed blender, 69 cu. ft.
1—Sturtevant #7 dustite rotary batch blender, NEW.
15—Robinson Type 304 stainless steel horiz. blenders, 255 cu. ft.
1—Robinson Type 304 stainless steel horiz. blender, 125 cu. ft.
1—Baker Perkins 150 gal. dispersion type mixer, complete.
1—J. H. Day 5 gal. double arm sigma blade mixer, stainless steel.
1—Stokes stainless steel granulating mixer, Model 21-J.
1—Patterson-Kelley stainless steel twin shell blender, 2 cu. ft.

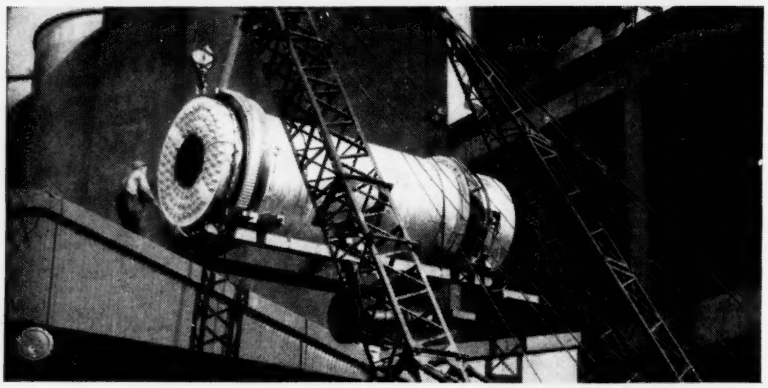
MISCELLANEOUS

1—Rietz stainless steel pilot plant grinder.
3—Mikro #3TH stainless steel pulverizers.
150—Worthite and Durimet centrifugal pumps, all sizes.
2—Mikro Bantam pulverizers.
1—Struthers Wells stainless steel 1150 sq. ft. single effect evaporator.
1—Swenson triple-effect evaporator, 5' diameter, 9' diameter, 9' diameter, complete.
2—Cleaver Brooks package steam generators, 150 HP and 500 HP, 160 psi.
1—Superior 300 HP package steam generator, 125 psi.
1—Sprout Waldron pelletizer, Type 501FF.
1—Williams "Comet" 4 roll mill, complete.
1—Raymond 2 roll high side mill.
1—Vulcan stainless steel bubble cap column, 4' dia. x 25 plates.
1—Griscom Russell stainless steel heat exchanger, 900 sq. ft.
3—Badger stainless steel heat exchangers, 500 and 600 sq. ft.
4—Patterson stainless steel condensers, 200 and 300 sq. ft.
20—Davis Engineering stainless steel heat exchangers, 102, 119, 136, 166 sq. ft., NEW.
4—Pfaudler glass lined thimble type condensers, 9, 14 and 62 sq. ft.

1—Stokes stainless steel jacketed rotary vacuum dryer, 3' x 10'.
1—Struthers Wells stainless steel rotary dryer, 5' x 25'.
2—ADT stainless steel lined rotary steam tube dryers, 42" x 30' long.
2—Young stainless steel 4 cu. ft. double ribbon blenders.

R. GELB & SONS, INC.
U. S. HIGHWAY 22, UNION, N. J. · MURDOCK 6-4900
75 ANNIVERSARY

CIRCLE FF ON READER SERVICE CARD



3 FLOORS UP

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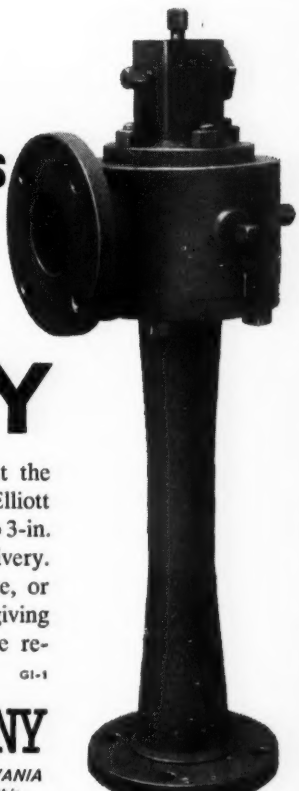

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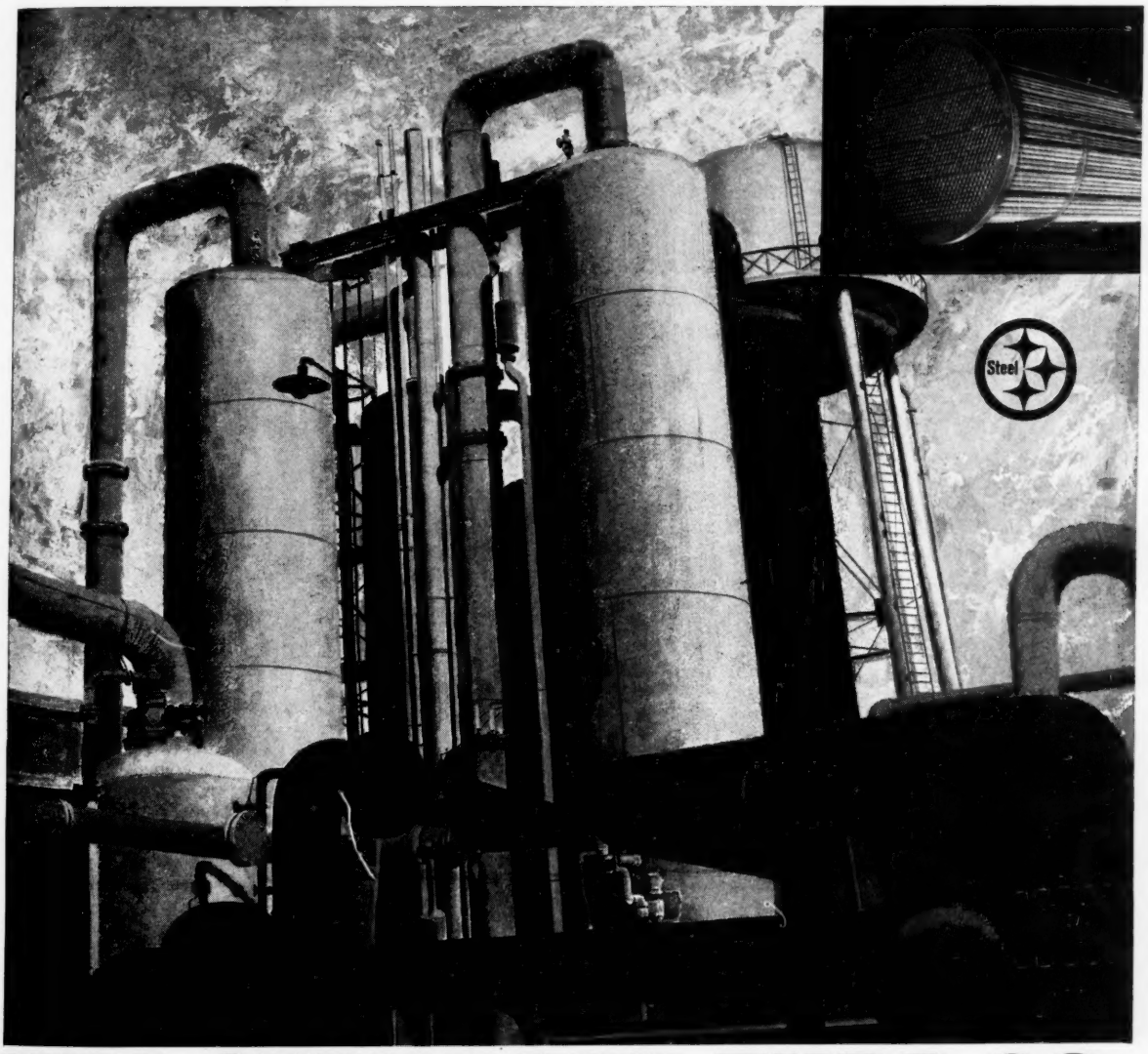

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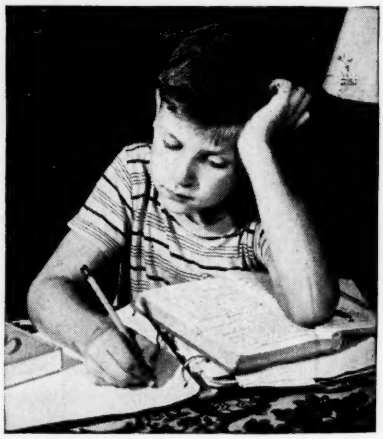

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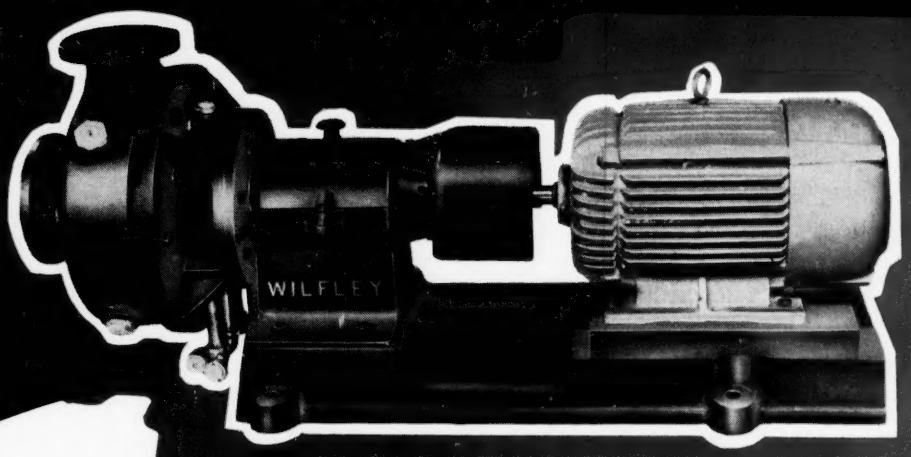

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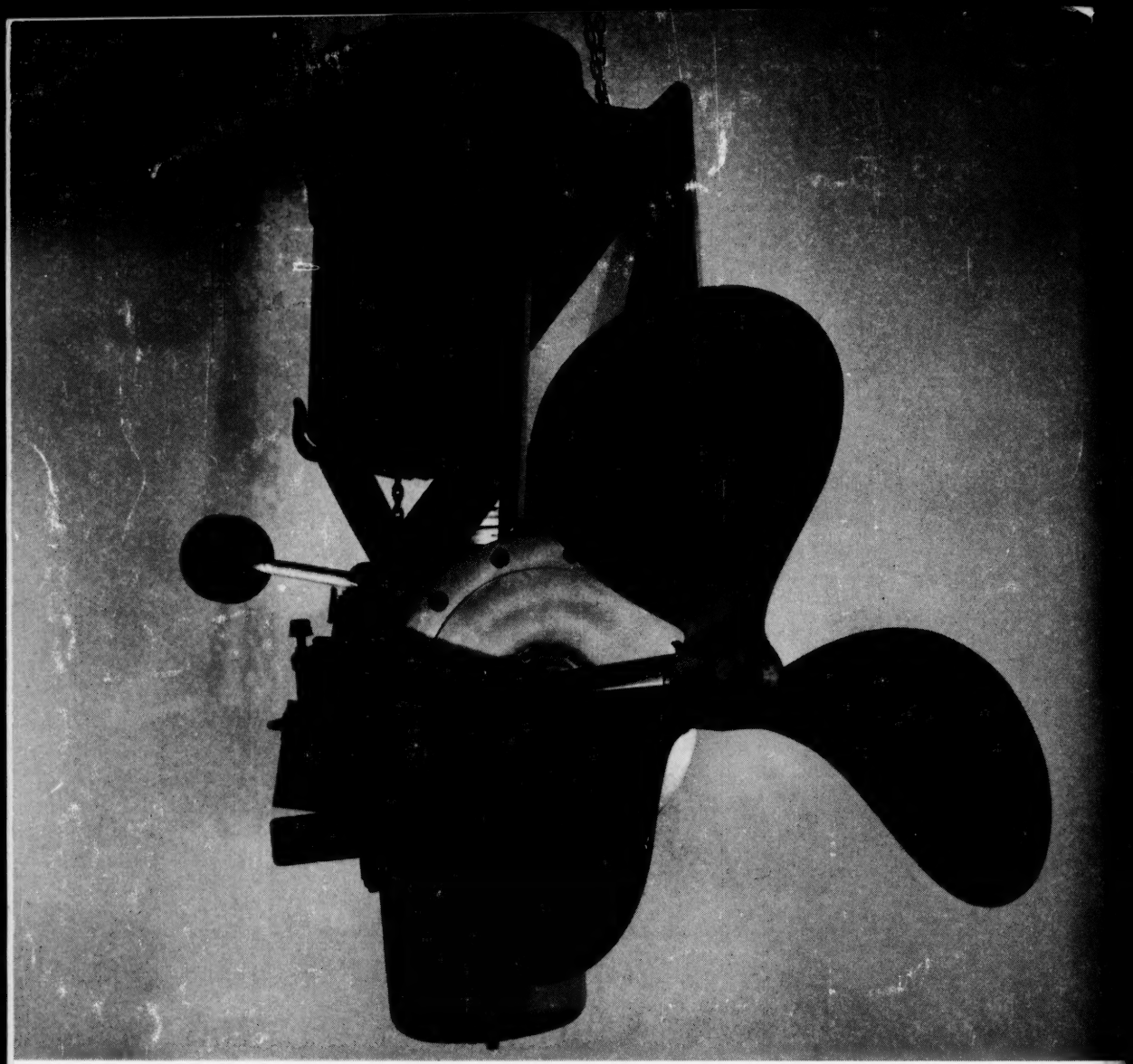

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